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CONTENTS

Preliminary Notes on the Biology of the St. Joseph River —*John S. Dolley* 193

Some Lizards from the Great Basin of the West and Adjacent Areas, with Comments on the Status of Various Forms—*Charles E. Burt* 228

Helminth Parasites of the Chicken, Gallus Domesticus, In Dallas County, Texas—*F. M. Adams* and *S. W. Geiser* 251

Pennsylvanian Ostracoda; a Continuation of the Study of the Ostracoda Fauna from the Wayland Shale, Graham, Texas—*H. N. Coryell* and *R. T. Booth* 258

Reversal of Valve Size and Hinge Structure in a Species of the Genus Cytheridea—*C. I. Alexander* and *C. W. Alexander* 280

Book Reviews 284

Note:— Contributions on general and midland natural history will be gladly received. Papers on botany and allied subjects, zoology, geology and physical geography, should be addressed to the respective editors, whose addresses are given on the cover. Authors of papers on geology and paleontology are asked to confer with the editors before preparing copy of illustrations.

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PRELIMINARY NOTES ON THE BIOLOGY OF THE ST. JOSEPH RIVER *

JOHN S. DOLLEY

INTRODUCTION

This paper is the result of a biological field survey at separate periods during which time special attention was given to that part of the St. Joseph River in the immediate vicinity of South Bend, Indiana, and from South Bend to Niles, Michigan. This part of the river is most grossly polluted with industrial and domestic wastes, the greatest volume of which comes from South Bend and Mishawaka in Indiana. According to Finch (1928-'30) the pollutional load originating from these two cities was estimated equal to the sewage of 150,000 people. As the St. Joseph River is not a large stream it can easily result that during a good part of the year the volume of water will not be sufficient to care for such waste with its complex protein compounds. This becomes evident within the limits of South Bend and Mishawaka where the organoleptic effects due to biolysis are especially offensive.

A study was made of the distribution of plant and animal species along the river as well as a survey of the general conditions with regard to pollution. With the latter idea in mind an examination of the plankton was made at various points to see whether pollution-enduring organisms were present. In addition the fish population of the river in this region was studied especially with reference to parasitic infection.

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* Contribution from the Zoological Laboratory of the University of Illinois, under the direction of Henry B. Ward, No. 437.

For the identification of invertebrate animals the Fresh Water Biology by Ward and Whipple proved most valuable. In determining Protozoa this was supplemented by Kudo's Handbook of Protozoology. For determining Vertebrates Pratt's Manual was used. In addition various other taxonomic works were consulted and the group of Mollusca was checked by Mr. F. C. Baker of the Museum of Natural History at the University of Illinois.

GENERAL DESCRIPTION OF THE RIVER

The St. Joseph River rises in the lake district of South Central Michigan and flows southwest into Indiana where it makes a great bend to the west and then to the north finally entering Lake Michigan at St. Joseph and Benton Harbor. Its total length in Indiana is about forty-two miles while its length from the Indiana-Michigan state line to its mouth is approximately forty-five miles.

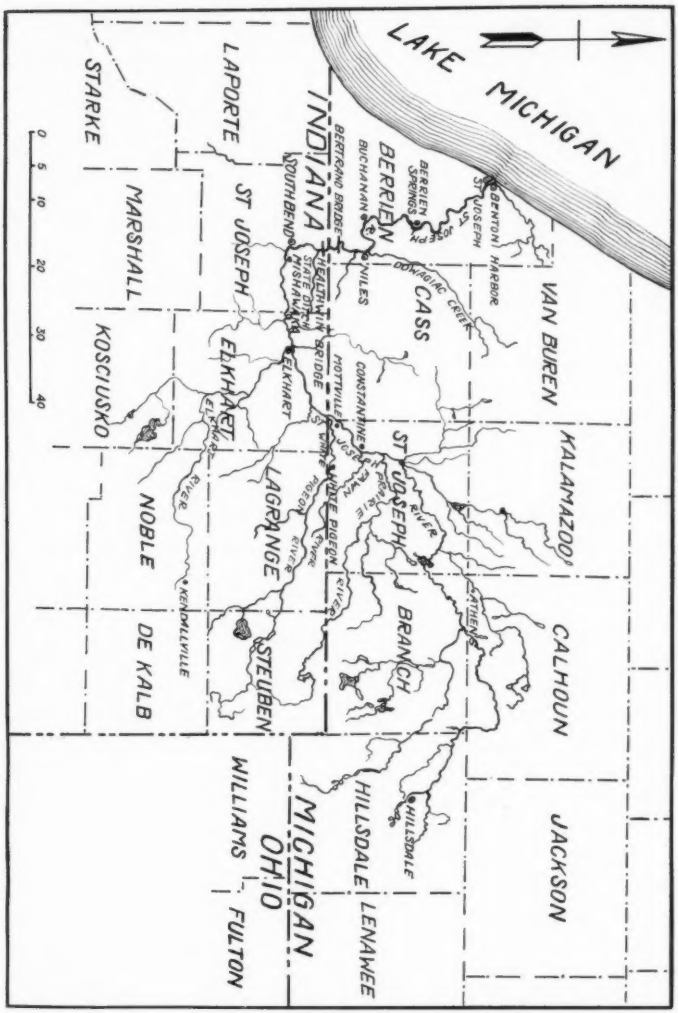
The drainage basin lies entirely within glacial drift and no bed rock is exposed. About four hundred lakes from five to one-eighth of a square mile or less form a large part of the natural water storage. The entire drainage area is about 4600 square miles of which 1,700 are in Indiana and 2,900 in Michigan. Map I shows the main branches of the drainage system.

In Indiana the average profile of the river is two and two-tenths feet per mile, while the profile downstream from the Michigan state line is one and five-tenths feet per mile. Thus the fall of the river in Indiana and below to Lake Michigan, about eighty-seven miles in all, is very slight compared to a seventeen and eight-tenths feet drop per mile for a distance of about fourteen miles in Michigan from Three Rivers to the Indiana-Michigan line.

Although comparatively small, the St. Joseph River has been used extensively for power sites. Along the river proper, dams are found at Three Rivers and Constantine, Michigan, and at Elkhart, Hen Island, Mishawaka and South Bend in Indiana. Dams are located at Niles, Berrien Springs and Buchannan, Michigan. Of these three the one at Berrien Springs forms the largest reservoir, Lake Chapin.

MAP I

Map of the St. Joseph River drainage system taken with modifications from U. S. Geological maps of Indiana and Michigan.



Map I

Map of the St. Joseph River drainage system taken with modifications from U. S. Geological maps of Indiana and Michigan.

A very striking feature of the river between South Bend and Niles is the fact that several species of pond weeds of the genus Potamogeton grow in wide beds across the river in the shallower parts. The very fact that thes plants grow in such large patches indicates the sluggish nature of the river; however, some of the swiftest parts occur where these weeds grow thickest. Apparently the sandy loam of the river bed is very favorable to their development, but undoubtedly the volume of human excrement coming from South Bend and Mishawaka is contributing greatly to their growth and abundance. Large patches of these weeds occur: just upstream from M 31 State Route bridge in South Bend, behind St. Mary's College, at the mouth of state ditch, just below the Healthwin bridge and about one-half mile below Bertrand bridge in Michigan. Wherever there is a lot of Potamogeton the water is not over ten feet deep and often less. Ordinarily the depth of the river does not exceed fifteen feet even in the deepest places.

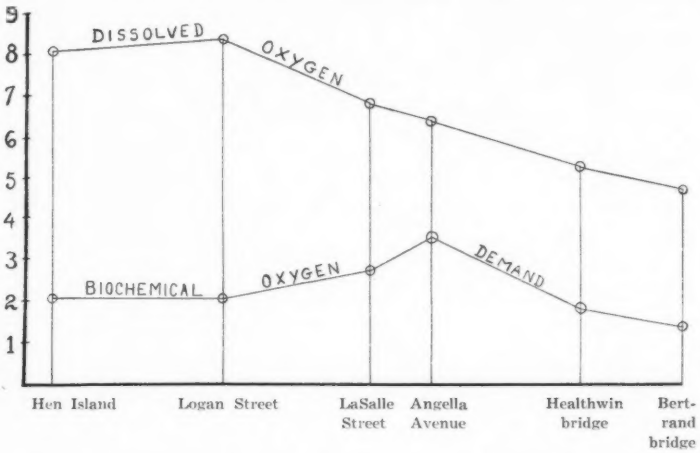
POLLUTION OF THE RIVER

The Department of Sanitary Engineering of the Indiana State Board of Health under the direction of L. S. Finch made a survey of the river in the South Bend-Mishawaka area during the fall of 1927, the summer of 1928 and the summer and fall of 1929. In 1929 samples for the determination of dissolved oxygen, biochemical oxygen demand, percentage saturation of oxygen, turbidity, temperature, and *Bacterium coli* were taken at seven points from Hen Island Dam in Mishawaka to Bertrand bridge in Michigan. In addition data showing the amount of water available in the receiving stream were secured from the Indiana-Michigan Electric Company at Hen Island. These data indicated that during most of the year there was insufficient water to take care of the large volume of sewage, and examination of samples of water from the river bore out this observation.

The Stream Control Commission of the Michigan State Department of Health under direction of M. P. Adams made extensive field studies of chemical, physical and bacteriological conditions in the St. Joseph River from July 15 to December 1, 1931. On the average four water samples were taken

at each station, but between Niles, Michigan and South Bend as high as thirty or more samples were taken at a station. Their data on dissolved oxygen together with those of Finch (Graph A), indicate the effects of pollution especially from South Bend to Niles. Adams' data (Graph B) are in general agreement with those of Finch, but indicate average values for oxygen much lower between Logan Street in South Bend and Healthwin bridge four miles below. Average values of less than three parts per million at Angella Street in South Bend, and at Healthwin bridge are unfavorable to most species of fresh water fish and explain in large part why no fish except carp were caught in the river between these two points.

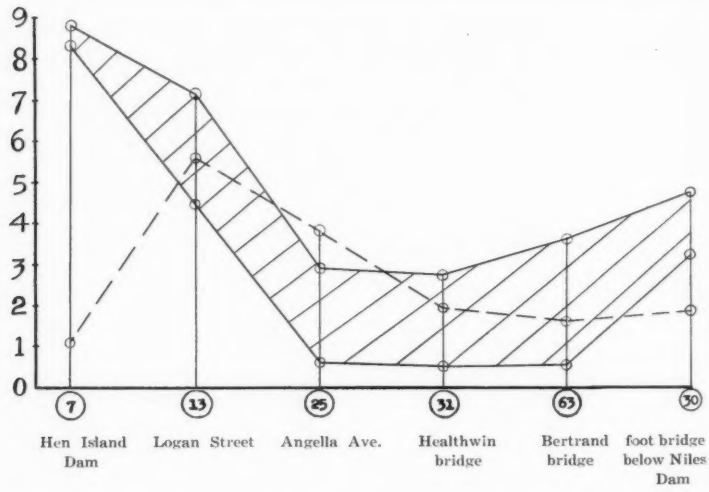
The worst effects of pollution as evidenced from the data



GRAPH A — Showing dissolved oxygen and biochemical oxygen demand at points below South Bend and Mishawaka in the St. Joseph River. These data represent averages of nine samples taken at the stations indicated between July 19, and October 10, 1929, by the Indiana State Department of Sanitary Engineering.

The vertical scale of the graph represents parts per million. Points on the horizontal axis indicate sampling stations below Mishawaka and South Bend. The first station, Hen Island, is the only one in Mishawaka. Logan Street forms the eastern limits of South Bend. Healthwin bridge and Bertrand bridge are north of South Bend (Map 1 and 3).

of the Michigan Department of Health, occur between west South Bend and the southern limits of Niles. Between La Salle Street in South Bend to a point two miles below the city the biochemical oxygen demand exceeds an average dissolved oxygen of 3 parts per million. Also in this locality the *B. coli* count is highest being 200,000 per cubic centimeter of water. A similar count was obtained by Finch (1929). The only other locality where the dissolved oxygen is very low and is exceeded by the biochemical oxygen demand is just below Hillsdale, Michigan at the headwaters of a small stream which joins the St. Joseph at Three Rivers.



GRAPH B — Data comparable to those taken by the Indiana State Board of Health, 1929. Oxygen in parts per million are plotted on the vertical axis and stations at which samples were taken are shown on the horizontal axis. The numbers along the horizontal axis represent the number of samples taken at separate stations. The broken line indicates oxygen as average biochemical oxygen demand. The line at the top of shaded area represents average dissolved oxygen while that at the base of this area shows the minimum dissolved oxygen. These data were collected by the Michigan Stream Control Commission of the State Department of Conservation in a survey of pollution conditions in the St. Joseph River from July 15 to December 1, 1931.

In consideration of these chemical and bacteriological data, the low profile of the river from South Bend to Lake Michigan, the low water supply in summer months, and the presence of four power dams between Mishawaka, Indiana and Lake Michigan, the serious nature of the pollution problem below South Bend is readily realized.

DESCRIPTION OF THE RIVER IN MISHAWAKA, SOUTH BEND AND NORTHWARD TO NILES, MICHIGAN

THE MISHAWAKA REGION

The river flows through the northern tip of Mishawaka. That part flowing through the northeast part of the city is relatively free from pollution except for occasional private sewage effluents. This portion of the river is supplied with bivalve molluscs which according to mussel fishermen occur here and upstream. Downstream they become fewer in numbers and species until below the dam in South Bend there are few if any of the abundant form, *Actinonaias carinata* (Fig. 8).

No live bivalves occur again until Berrien Springs, Michigan, about twenty miles downstream. The bivalves that are commonly taken in and above Mishawaka are shown in figures 1 to 9. Of these the most frequent species encountered are: the lady finger shell, *Elliptio dilatatus delicatus*, Actinonaias, and *Lampsilis ventricosa*. Wenninger (1921) has reported 15 species from the South Bend region, four of which were found in this survey: *Alasmodonta marginata*, *Anodonta grandis*, *Lampsilis ventricosa*, and *Lasmigona costata*.

Gastropods are plentiful in the river in northeast Mishawaka, Pleurocera being by far the most abundant with Campeloma occurring less frequently. These did not occur below the dam in South Bend nor between there and Niles. In this part of the river in Mishawaka the larger water plants Potomageton, Elodea and Ceratophyllum are abundant and furnish both food and protection for the large numbers of snails. The bottom here is sand and thickly covered with blue green algae. From this point downstream to the eastern city limits

of South Bend, the river is deeper, the bottom continues sandy and along the banks for several yards into the river is a layer of algae, Oscillatoria on the bottom. The Pleurocera become progressively less numerous. Shortly above Main Street the river is split; the northern branch is obstructed by a dam with a spillway about twenty feet high. The other channel of the stream goes to the left to the Mishawaka Rubber and Woolen Company to form a millrace before again entering the main stream.

Although sewage is being continually emptied into the river in Mishawaka the volume is not so great on the whole; large quantities, however, come from the packing house at Logan Street, which street runs perpendicularly north and south and serves to form the northwest limits of the city. Also a great deal comes from the Mishawaka Rubber and Woolen Company located by the river on Main Street.

THE SOUTH BEND REGION

After leaving Mishawaka the river is shallower and not so swift. The aquatic plants which occurred in Mishawaka are seen less frequently. Also the concentration of sewage is greater. Consequently the snails are only occasionally seen; those, however, above Sample Street are the same that occur in Mishawaka. Invertebrates in general are scarce. Among crayfish the few that were found were of three species, *Cambarus propinquus* Girard, *Cambarus virilis* Hagen and *Cambarus blandingi acutus* (Girard). Between Sample Street and the city dam just above Colfax Street, which is the heart of the business district, practically no invertebrates exist except those in the plankton which contained quite a variety of rotifers, Cyclops and Protozoa. It can be seen from Graph A that the dissolved oxygen in this region between Logan and LaSalle Street shows its most rapid decline. It is between Sample Street and M 31 State bridge that the greatest concentration of sewers occurs. No fish were taken from this region except carp. Three small mouth black bass were taken a short distance above Logan Street; two of these were heavily infected with Holostomata metacercaria cysts which occurred in the flesh along the dorso-lateral region. These

cysts are very small, being scarcely a millimeter in diameter and are easily overlooked although many of the cysts have a black-mottled outer wall. Fishermen reported having caught bluegills in east South Bend during the summer.

Below the dam between Navarre Street and M 31 bridge the gastropods again appear along the banks where Elodea is abundant especially along the west shore at the end of Navarre Street. The species are different from those occurring in east South Bend, (Fig. 12-14). *Stagnicola palustria,* and *Helisoma trivolis* are most numerous while *Physa gyrina* is found only occasionally. Except in a few places several varieties of Potamogeton are to be found growing in mid-stream from Navarre Street northwest to just beyond St. Mary's College a little over a mile downstream. Below Angella Avenue the river widens, swerves to the right and then narrows again to swerve sharply to the left. The right bank in this region is high and well covered with maple, ash and linden trees. Below St. Mary's the river makes a very sharp turn to the right, there being marshy ground at the point 8 and a small slough at 8_1, Map III. The river turns again sharply to the left forming a low penninsular flood plain on the left. A creek which drains a large swamp enters on the right at this bend. In the slough, 8_1, there are great numbers of the small frog *Acris gryllus* (Le Conte), and Stagnicola is abundant. The slough is bordered by rushes (Juncus) and sedges, (Carex), and is full of Hydrodictyon and hornwort (Ceratophyllum). In here also are quite a number of painted turtles, *Chrysemys marginata.* Just at the north city limits of South Bend is another sharp turn to the right forming on this side another low penninsula covered with maple, willow and poplar trees.

THE RIVER BETWEEN SOUTH BEND AND NILES

The river widens out below the city and again becomes choked with pond weeds. Here the water is swift as it was also just above St. Mary's College. Just before reaching the mouth of the state ditch, a small spring-fed creek enters from the right bank. To the south of this there is a heavily wooded flood plain of linden, oak and sycamore. In the small creek a

large species of amphipod, *Dikerogammarus fasciatus** occurs in large numbers under the stones of the creek bed.

Between Healthwin and Bertrand bridges the river flows through low ground most of the way. At the first large turn to the right about one half mile below Healthwin bridge is a small island covered with maple, elm and sycamore. Another small island covered with maple and willow trees is located off the east bank just above Bertrand bridge. Below Bertrand the river forms a huge double U curve. Here the channel gets narrower and deeper. A small creek enters from the west bank at the base of the first U. At the head waters of this creek which is fed by a spring one female specimen of *Cambarus gracilis* Bundy was taken. Hay (1896) says this form is a burrower. Although it was taken from the stream I noticed its burrows along the clay banks. It is a very small decapod. Hay gives its length as 62 mm.

The river turns sharply below the entrance of this creek to form the second U curve. On the right hand bank as is shown on Map III the ground is marshy and there is a slough adjoining the river. This is heavily overgrown with Ceratophyllum, Elodea, Hydrodictyon and Lemna. In here turtles are abundant including *Chrysemys picta* (Schneider), *Chrysemys marginata belli* (Gray), *Graptemys pseudogeographica* (Gray) and *Emys blandingi* (Holbrook). One female individual of the last named species was captured while feeding with its head buried in the mud and debris of the bottom. This species is a large tortoise-like form with its body often growing too big for its shell. Its type locality is the Fox River in Illinois. This specimen had seven leeches, *Placobella parasitica* (Say) clinging to its plastron and legs. Below this slough and around the second U turn is a smaller slough filled with water-lilies and Elodea in which a colony of Bryozoa, *Pectinatella magnifica* Leidy, measuring about seven by four inches was taken. Great numbers of these colonies occur just above Berrien Springs in a bayou adjoining Lake Chapin.

From this point northward the river has many bayous or

* Identified by Mr. J. G. Mackin, East Central Teachers' College, Ada, Okla.

sloughs occurring on either side in which snapping turtles *Chelydra serpentina* (Linn.) are often found and less often the leather back *Amyda spinifera* (LeSueur). One of these was taken in the bayou on the west bank above No. 19, (Map III). Also *Rana pipiens* Schreber, *Rana clamitans* Latreille, and the bull frog *Rana catesbiana* (Shaw) are found in such bayous. Thompson, C. and Thompson, H. (1912) report these and *Acris gryllus* for Van Buren and Cass Counties which are adjacent to Berrien and contain tributaries of the St. Joseph River.

Between Bertrand and Niles the two species of crayfish which are most common are *Cambarus blandingi acutus* (Girard) and *Cambarus virilis* Hagen. These occur in great numbers in Brandywine bayou and along both banks of the river for a mile southward. These have increased greatly in numbers recently and furnish food for several species of fish in this part of the river. Bass and sunfish whose viscera were examined showed that they had been depending largely on the crayfish for food. Only a very few crayfish were found in South Bend and decapod Crustacea were noticeably scarce below South Bend until points below Bertrand were reached. Forbes and Richardson (1913) in their study of the upper Illinois River state that in the "septic" or "saprobic" part which included the sanitary canal at Lockport 33 miles below its source, neither Crustacea nor snails were to be found. The average dissolved oxygen here was four parts per million. In the Des Plaines River at Dresden Heights and the Illinois River from here to Marseilles there was no great difference in oxygen content although the river was polluted, yet here Elodea, Potamogeton and Myriophyllum were abundant and several species of snails including *Helisoma trivolvis* and *Physa gyrina* were present. No crawfishes were found until just above the dam at Marseilles where a few were found at the entrance of a small creek. This part of the Illinois River for a stretch dowstream of 26 miles, and the Des Plaines River at Dresden Heights 16 miles below the mouth of the Sanitary Canal, these authors designated as "polluted" or "pollutional." The Illinois River from Marseilles to Starved Rock, 16 miles, they labeled "contaminated" or "contaminate."

The water here was grayish and disagreeable in odor as in the previous section, and in the Des Plaines River; but snails and crawfishes were more numerous. The next section of the river, extending 49 miles below Starved Rock, they called "relatively pure water," in which pollutional organisms occur only occasionally and the water is made green by chlorophyll-bearing plankton. There is also a large variety of insect larvae, mussels, snails and Crustacea. Sponges, leeches, Bryozoa and planarians are fairly common.

On the basis of the classification of Forbes and Richardson (1913), using snails, bivalves and decapod Crustacea as animal indicators and the odor and appearance of the water as further evidence it can be said that the St. Joseph River in and below South Bend to Bertrand is polluted and below Bertrand to Niles it is contaminated. These conclusions will be further amplified by a consideration of the microplankton.

The following is a list of birds commonly seen along the river:

Ceryle alcyon (Linn.), belted kingfisher
Oxyechus vociferus (Linn.), killdeer
Actitis macularia (Linn.), spotted sandpiper
Butorides virescens (Linn.), green heron
Botaurus lentiginosus Stephens, American bittern
Ardea herodias (Linn.), great blue heron
Anas platyrhynchos Linn., common mallard
Larus argentatus Pontoppidan, herring gull

THE MICROPLANKTON

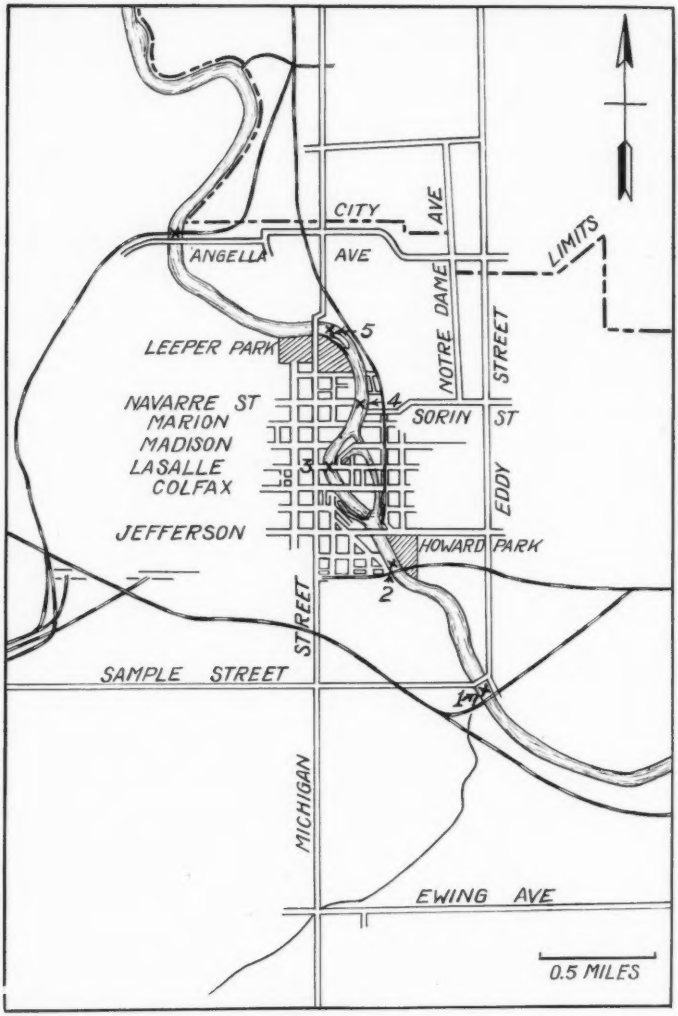
Plankton samples were taken at 19 points beginning in South Bend and ending just south of Niles, Michigan. In so far as no quantitative estimations were made the conclusions with respect to pollution indicators are of necessity qualitative. Concerning the significance of quantitative plankton data in pollution work, Wiebe (1927) in a pollutional survey of the upper Mississippi River found no correlation between the total number of plankton individuals and the degree of pollution and therefore concluded the abundance of plankton cannot be employed as a criterion of the degree of pollution. He further says that his samples show that plankton organ-

isms most abundant in unpolluted waters are in general also most abundant in grossly polluted waters. His investigations were made only during the summer season. The plankton stations are indicated on Maps II and III showing the course of the river in South Bend and the same from South Bend to Niles. The distance from South Bend to Niles by river is approximately 11.5 miles.

A tow-net of the Kofoid type with number 20 bolting cloth was used in collecting all samples except those off sewage effluents in which cases an ordinary wide mouthed bottle 14 mm. high by 6 mm. in diameter was used. Therefore the samples off sewage effluents do not represent so great a volume or number of plankton organisms as do the net hauls.

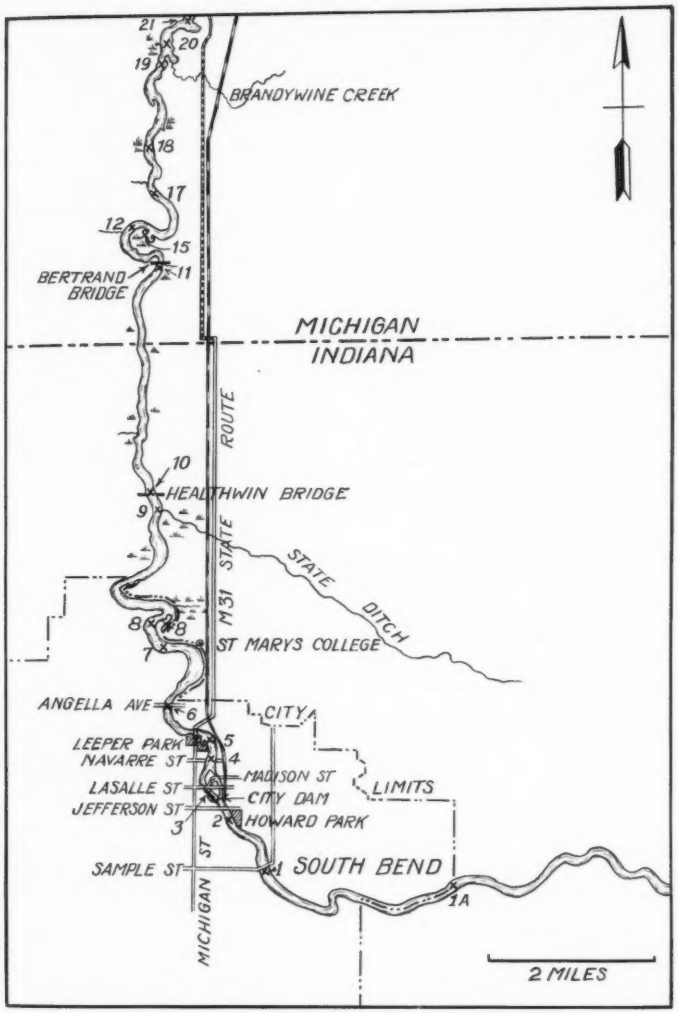
DESCRIPTION OF PLANKTON STATIONS

1. Off sewage effluent from the northeast shore above Sample Street Bridge.
1a. Logan Street Bridge, West Mishawaka, in midstream.
2. Off sewage effluent coming from Howard Park on east bank.
3. Midstream beneath the LaSalle Street Bridge.
4. Off sewage effluent at the end of Navarre Street on west bank.
5. Off sewage effluent from Leeper Park.
6. Beneath Angella Avenue Bridge in midstream.
7. Off sewage effluent 0.4 miles below St. Mary's College; off west bank.
8. Off sewage effluent 0.5 miles below St. Mary's College; off west bank.
8_1. In slough off east side of the river, about 400 yards below station 8. Water four to five feet deep, bordered by rushes (Juncus).
9. At the mouth of the state ditch just above Healthwin Bridge.
10. In midstream just below Healthwin Bridge.
11. Bertrand Bridge in midstream.
12. First *U* turn below Bertrand; midstream in deep water.
15. One hundred yards below station 12, in slough off southwest bank.
17. In midstream three miles above Niles, Michigan.
18. In midstream two miles above Niles, Michigan.
19. In midstream one and a half miles above Niles, Michigan.
20. In midstream just opposite the mouth of Brandywine creek.
21. In midstream above Niles dam.



MAP II

Map showing in detail that part of the St. Joseph River in South Bend from Sample Street to Angella Avenue. This portion of the river flows through the center of the business district. Plankton sampling stations are indicated by numbers opposite the respective sampling points.



MAP III

A map of the river from the east city limits of South Bend to the power dam at Niles, Michigan showing all the plankton sampling stations. These are indicated by numbers as in Map II. Immediately east of South Bend on both sides of the river is the twin city of Mishawaka.

MICROPLANKTON TABLES*

1. Protozoa

	Stations							
	6	3	18	7	4	2	5	1
Phacus pleuronectes (Ehrenberg)	X							
Arcella discoides Ehrenberg	X							
Difflugia sp.	X							
Peranema trichophorum (Ehrenberg)	X							
Volvox spermatosphara Powers	X	X						
Epistylis plicatilis Ehrenberg	X		X					
Euglena oxyuris Schmarda	X	X	X					
Pleodorina illinoisensis Kofoid	X	X						
Centropyxis aculeata Stein	X	X	X					
Eudorina elegans Ehrenberg	X		X	X				
Pleodorina californica Shaw	X	X	X	X				
Euglena spirogyra Ehrenberg	X	X	X	X		X		
Pandorina morum (Müller)			X				X	
Euglena viridis Ehrenberg			X	X				
Phacus longicaudus (Dujardin)			X					
Zoothamnium adamsi Stokes			X					
Thuricola valvata Wright			X					
Stentor coeruleus Ehrenberg			X					
Euglena acus Ehrenberg			X					
Stephenosphaera pluvialis Cohn		X	X					
Ceratium hirundinella Müller		X	X					
Actinobolus radians Stein		X						X
Pyxidium ramosum Stokes		X		X				
Vorticella campanula Ehrenberg	X		X				X	
Euplotes charon (Müller)	X		X				X	
Enchelys pupa Ehrenberg								X
Frontonia leucas Ehrenberg							X	
Paramecium caudatum Ehrenberg							X	

2. Turbellaria

	Stations	
	6	11
Planaria simplex Woodworth	X	X
Microstomum caudatum Leidy	X	

3. Annelida

	6	12
Stylaria lacustris (Linné)	X	
Aeolosoma hemprichi Ehrenberg	X	
Chaetogaster sp.	X	
Tubifex multisetosus (S. Smith)	X	X

* The microplankton has been divided into nine tables containing forms from as many groups taken at the various stations which stations have been described on page 205

4. Rotatoria	Stations									
	6	3	17	4	2	19	12	7	5	1
Megalotrocha alboflavicans Ehrenberg (colony)	X									
Salpina spinigera Ehrenberg	X	X								
Rattulus longiseta Schrank	X	X	X							
Notops pelagicus Jennings	X	X								
Brachionus pala Ehrenberg	X	X		X		X				
Anuraea cochlearis Gosse	X	X	X	X	X	X				
Polyarthra platyptera Ehrenberg	X					X				
Brachionus punctatus Hezpel	X					X				
Monostyla lunaris Ehrenberg	X					X				
Cathypna luna Ehrenberg	X					X				
Pterodina sp.	X	X								
Notholca longispina Kellicott	X	X				X				
Rotifer neptunius Ehrenberg	X	X	X			X		X		
Triarthra longiseta Ehrenberg	X		X							
Diplois daviesiae Gosse	X									
Noteus quadricornis Ehrenberg	X									
Rattulus cylindricus Imhoff						X			X	
Pleosoma truncatum Levander						X				X
Synchaeta stylata Wierzejski						X				

5. Gastrotricha	Stations
	17
Chaetonotus similis Zelinka	X

6. Cladocera					
	6	13		4	19
Leptodora kindtii (Focke)	X				
Ceriodaphnia acanthina Ross	X	X			
Bosmina obtusirostris Sars	X	X			
Diaphanosoma leuchtenbergianum (Fischer)	X	X			
Polyphemus pediculis (Linné)	X	X			
Ceriodaphnia laticaudata P. E. Müller		X			
Scapholeberis aurita (Fischer)		X			
Leydigia acanthocercoides (Fischer)		X			
Ceriodaphnia rotunda Sars		X			
Diaphanosoma brachyurum (Liéven)		X			
Chydorus sphaericus (O.F.Müller)		X			
Sida crystallina (O. F. Müller)		X			

Bosmina longirostris (O.F.Müller)				X		X		X				
Scapholeberis mucronata (O. F. Müller)								X				
Moinodaphina macleayii (King)								X				
Eurycercus lamellatus (O. F. Müller)								X				
Acropterus augustatus Sars								X				
Ceriodaphnia rigaudi Richard								X				

	Stations											
7. Copepoda	*			*			*	*		*		
	9	4	2	8_1	3	11	10	21	8	6	20	15	18
Cyclops albidus Jurine	X	X	X		X	X	X	X		X			
C. bicuspidatus Claus.	X												
C. fimbricatus Fischer.		X	X	X		X							
C. prasinus Fischer	X	X	X	X	X	X	X			X			
C. aequoreus Fischer	X	X	X	X	X		X		X	X			
C. viridis Jurine		X											
C. phaleratus Koch			X										
C. viridis brevispinosus (Herrick)			X	X	X				X	X			
C. serrulatus Fischer.			X	X	X	X	X	X	X		X		
C. leuckarti Claus					X	X							
Canthocamptus staphylinoides Pearse										X		X	X

8. Ostracoda	6
Cypris americanus Cushman	X

	Station
9. Hydracarina	19
Limnesiopsis sp.	X

Note. * Plankton examined for Copepoda only.

WINTER MICROPLANKTON TABLES†

Crustacea collected November, 1932. (Temperature 1°-3° C.)

Amphipoda	Stations	
	1a	1
Hyalella knickerbockeri	X	X

Cladocera	2	4	1a	1	7	3	6
Bosmina longirostris	X	X	X	X	X	X	X
Chydorus sphaericus	X	X	X	X			
Alona affinis		X		X	X	X	X
Chydorus ovalis		X	X	X			
Pleuroxus striatus		X	X		X		
Alona intermedia		X		X			
Leydigia acanthocercoides			X				
Alonella dentifera			X				
Pleuroxus denticulatus				X			
Simocephalus serrulatus				X			

Copepoda	3	6	7	4	2	1	1a
Diaptomus oregonensis	X	X	X	X	X	X	X
Cyclops prasinus	X		X	X	X	X	
Cyclops viridis brevispinosus	X	X	X	X		X	X
Canthocamptus staphylinoides		X	X	X	X	X	X
Diaptomus birgei		X	X		X	X	
Cyclops fimbricatus		X	X		X	X	X
Cyclops bicuspidatus		X	X				X
Cyclops albidus		X	X		X		X
Cyclops aequoreus		X		X			
Cyclops serrulatus				X	X	X	
Diaptomus stagnalis						X	X

† While the manuscript was in process of preparation an opportunity to study the winter plankton was afforded. Consequently additional tables of Crustacea have been added. The winter collections include an additional station, 1a, which is listed under the Description of Plankton Stations. The temperatures indicated represent water temperatures in midstream. The plankton hauls were made at a depth three to six feet below the surface in midstream. A Kofoid tow net was used in taking the samples, care being taken that approximately the same volume of water passed through the net at each haul.

Crustacea collected December, 1932. (Temperature 0°-2.5° C.)

Cladocera	Stations						
	10	3	21	8	9	7	11
Bosmina longispina	X	X					
Chydorus sphaericus		X	X	X			
Alona affinis	X	X	X		X		
Bosmina longirostris	X	X		X	X	X	
Daphnia retrocurva		X					
Alona quadrangularis			X	X		X	
Ceriodaphnia sp.						X	
Alona costata							X

Copepoda	Stations									
	4	3	8	6	7	9	21	10	1	11
Cyclops fimbricatus	X	X								
Cyclops aequoreus	X		X	X	X	X		X	X	X
Cyclops viridis brevispinosus		X	X	X	X	X	X			
Cyclops prasinus		X						X		
Diaptomus oregonensis		X		X	X	X	X	X	X	
Cyclops bicuspidatus				X		X	X	X		X
Canthocamptus staphylinoides		X				X	X	X		X
Diaptomus birgei						X				
Cyclops serrulatus										X

SIGNIFICANCE OF PLANKTON ORGANISMS

The following organisms may be taken as indicative of pollution: *Euglena oxyuris, Euglena acus, Epistylis plicatilis, Anuraea cochlearis, Aeolosoma hemprichi.* Marsson (1911) says that the flagellates of the genus Euglena are of great importance in the transformation of putrescent matter. They absorb such matter directly and also produce oxygen, thus oxidizing compounds that have been reduced by putreafctive fermentation. Where found plentifully in plankton they afford proof that the water has been contaminated.

Purdy (1929) found Aelosoma and Chaetogaster in the Ohio River wherever the water was badly polluted. Forbes and Richardson (1913) found these two annelids as well as the protozoan Epistylis to occur regularly in badly polluted water of the Illinois River.

In general a greater variety of species of plankton organisms occurred at station No. 6 and also a greater majority of pollution organisms, notably Protozoa, occurred at stations in South Bend while fewer such forms were found below Bertrand. This indicates the greater amount of organic matter and greater concentration of pollution near South Bend and the less concentrated condition on approaching west Niles.

Although not listed in the microplankton tables the pollutional fungus, Saprolegnia, and the blue green alga, *Oscillatoria limosa* probably, occurred frequently in plankton samples at South Bend and below to Niles, Michigan. *Oscillatoria limosa* occurs frequently as a heavy coating on stones in the river below Mishawaka. It has also been reported from the effluent of filter beds in the sewage disposal plant at Decatur, Illinois (Agersborg 1929).

SEASONAL OCCURRENCE OF CRUSTACEA IN RELATION TO THE SPREAD OF THE BROAD FISH TAPEWORM *DIPHYLLOBOTHRIUM LATUM* (LINN.).

The early life history of *D. latum* has only recently been experimentally worked out in North America (Essex, 1927). Although many points in the life history are not definitely known particularly those stages spent in fish it is now generally agreed that the life history is as follows: The eggs laid in the alimentary canal of man or other mammals (Vergeer, 1928, emphasizes the importance of wild carnivora as disseminating agents of the broad tapeworm) are evacuated with the feces. At certain periods whole segments filled with ripe eggs are evacuated. After lying in the water for some days or weeks they hatch into ciliated larvae called coracidia. Essex found 11 days to be the average time to hatch in lake water or tap water, in light or darkness. Thomas (1930) found that most eggs hatch in 12 days at room temperature but on the other hand some eggs hatched viable larvae after more than two months at this temperature. The free swimming coracidia are ingested by Copepoda and if the proper species is infected they lose their ciliated coat and penetrate the digestive lining, coming to lie finally in the body cavity. Essex infected experimentally *Cyclops viridis brevispinosus, C. prasinus* and *Diaptomus oregonensis.* Two new first in-

termediate hosts have recently been reported from lakes of Northern Minnesota by Magath and Essex (1931). These are *Diaptomus sicilis* and *Diaptomus siciloides*. After two or more weeks growth the larva becomes about 0.5 mm long and is known as a proceroid. If an infected copepod is eaten by a fish the young worm is freed in the intestine, burrows through the intestinal walls and comes to lie in the muscles or viscera where it is known as a plerocercoid and may vary from a few millimeters to 30 mm in length. In North America the fish which have been found to harbor the plerocercoid are the pike (*Esox lucius*), wall-eye (*Stizostedion vitreum*), yellow perch (*Perca flavencens*) and the burbot (*Lota maculosa*). Man becomes infected by eating raw or poorly cooked fish. There is some doubt as to whether the burbot is a natural second intermediate host in North America. Wardle (1933) records larvae from the burbot and sand pike taken from Lake Winnipeg but his records are not corroborated by feeding experiments.

In recent years the number of native cases of broad fish tapeworm infection is increasing, Barron (1929), Lyon (1929), Ward (1930), Plotz (1932), Waters and O'Connor (1932). However, as yet there appears to be three major endemic foci in North America, the lakes of Manitoba especially around Winnipeg, the Great Lakes region and the lakes of northern Minnesota in the United States.

Lyon (1920, 1926, 1929) has reported three native cases of *D. latum* infestation from South Bend, Indiana. From the second case reported by Lyon which was a Jewish boy aged four years, he estimated that a person harboring a fish tapeworm might expel into the South Bend sewerage system about 1,000,000 eggs daily. These would eventually reach the St. Joseph River and infect the proper crustacean host if present.

Essex (1929) examined fish from the Mississippi River in Minnesota and Wisconsin, the St. Croix River and from Long Lake and Lake Mazaska in Minnesota. Out of 226 fish examined only five were infected with *D. latum* these coming from Long Lake. From this he was inclined to believe that it would be surprising to find river fish infected with *D. latum* inas-

much as *Diaptomus oregonensis* the first intermediate host in Long Lake is typically a lake form.

Although I have not found any fish from the St. Joseph infested with *D. latum* larvae (Table A), it is possible that such larvae may have been overlooked during the process of examination; also comparatively few fish which are the proven hosts of the broad tapeworm were examined from the river. However from an examination of the plankton tables it will be seen that the first intermediate host of *D. latum* is not lacking in the St. Joseph River. Though *Diaptomus oregonensis* was not found in the summer collections it was the predominant species in the November collections and among the most abundant and frequently occurring forms in the December collections.

Whether the life history of *D. latum* could be successfully carried out in the river below South Bend has been questioned. Apparently much depends on the temperatures at which the eggs will develop normally in water, water currents, the presence of water barriers which would prevent free dissemination of eggs and the viability of plerocercoids exposed to variations in physical environment. Essex and Magath (1931) in studies on the viability of *Diphyllobothrium latum* ova found that the eggs in water when subjected to –10° C. for forty-eight hours were rendered non-viable. On the other hand they discovered that cultures of eggs held at a temperature of +15° C. for eight months developed normally when again placed at room temperature. Recent experiments have been carried on by Wardle (1933) on the toleration of *D. latum* plerocercoids to variations in environment. His data show that between 38° and –2.8° C. is most favorable to the survival of larvae in 0.2 molar sodium chloride solution and it was suggested that the median point of this range approximates the mean summer temperature of the host fish. Magath and Essex (1931) found that exposing infected fish to a temperature of –15° C. killed the larvae within twenty-four hours.

It seems that the fish most heavily infected with plerocercoids in North America is the pike or pickerel, *Esox lucius*. This species is known to be present in the St. Joseph River below South Bend. In fact it occurs in some numbers above

the dam at Niles, Michigan, at the entrance of Brandywine creek. Between South Bend and Niles there are no barriers such as power dams and the current is sufficiently rapid that infective eggs, even if they had a tendency to sink quickly, would be carried downstream several miles. Since raw sewage has been and is still being emptied into the river at South Bend it is entirely probable that a large percentage of infective eggs reaching the stream during the warmer months of Spring have hatched and been ingested by copepods which in turn have served to infect fish below the city. That human infections with the broad tape worm have not resulted or at least have not been reported is best explained by the fact that fish from the river below South Bend are not being used for food as freely on account of the known pollution of the water. As there are three dams between South Bend and the mouth of the river at Lake Michigan it is improbable that a great percentage of tapeworm eggs would travel fifty miles over three dams to hatch in Lake Michigan; on the other hand it is very likely that infected river plankton does reach the lake in some quantity. Also it is significant that lake fish frequently come up the river to Berrien Springs, Michigan, twenty-eight miles below South Bend.

THE DISTRIBUTION, ABUNDANCE AND SPECIES OF FISH PARASITES

During the summer of 1931 an attempt was made to determine the amount and nature of infestation of fish in the river between South Bend and Lake Michigan. The chief method of securing fish was by persuading fishermen who fished the stream to let me examine their catches for parasites. This method met with great difficulty inasmuch as practically no one was fishing then between South Bend, and Berrien Springs, Michigan, and comparatively few between there and Lake Michigan. Most fishing was being done at the mouth of the river or in the lake itself. The reasons for not fishing were obvious. In the first place the river water was unclean from a human standpoint, secondly the fish therein were only those which could survive a relatively low oxygen supply such as carp and occasionally bullheads. Thompson (1925) states

that carp and buffalo have been found living in water showing as low as 2.5 parts per million and as a rule a variety of fishes occur only when there is four or more parts per million. The greatest variety, he states, was taken when there were nine parts per million. The Michigan Stream Control Commission found the oxygen well over five parts per million from the lake to Buchanan, Michigan, a town located on the river about eighteen miles below South Bend.

Naturally, then, there were more kinds of fish to be caught closer to the lake and the fish were cleaner. The latter feature was a very large factor in the indisposition of fishermen to try their skill, and very frequent mention was made by Michigan fishermen of the inferior value of the St. Joseph River fish because they were "gassy." These men also complained of the inferior flesh of the fish. Thompson (1925) encountered the same condition in fish of the Illinois River. He describes it as like the smell of putrifying mud on the river bottom and the condition is definitely associated with prolonged periods of scanty supply of dissolved oxygen. From what men say who have known the St. Joseph River this condition of the fish was directly due to the emptying of large quantities of chemical waste into the river at South Bend several years ago which killed fish by the wagon-load. However, this condition is gradually becoming adjusted and eventually, provided some check is made on the emptying of raw sewage into the river, this stream will regain something of its former varieties of fish life. In fact there are still game fish occurring even as near to South Bend as Niles, Michigan; they do not possess that "gassy" odor nor is their flesh inferior, but these occur only where fresh water creeks come in or other places where the water is particularly well oxygenated.

During the summer of 1932 several factors combined made it such that more people were fishing in the St. Joseph River. In the first place the fish have come back and those which were never seriously threatened with extinction, namely the European carp, are quite as plentiful as formerly, and since they do not smell or taste any worse than other bottom feeding forms, are being utilized for food. Another reason for the use of these fish from a polluted river may be the depression

times and the consequent economic strain on those thrown out of employment. The catches of these men indicate that black bass, several species of sunfish, particularly bluegills, and suckers are to be found not infrequently in the river at South Bend, especially above the city dam. Also just south of Niles, Michigan, at the entrance of Brandywine Creek, there is a great quantity of suckers and carp and occasionally a pickerel, *Esox lucius*, is seen.

The suckers, *Catostomus commersoni* in the river just south of Niles, were found in 1931 with an acanthocephalan parasite, *Pomphorhynchus bulbocoli*. The infection was confined to the posterior part of the intestine where in almost every case the walls of the intestine were literally riddled by the hooked proboscides of these worms. Twenty-three suckers examined yielded an infection of 82 per cent. compared to an infection of three out of four examined in 1931 in the same locality. Another parasite, a cestodarian, *Glaridacris catostomi*, was found in these fish in the same part of the intestine. The parasites varied in size from one to fifteen millimeters and showed various stages of sexual maturity. The younger specimens were found grouped in deep cyst-like pockets as large as two millimeters in diameter located in the intestinal wall with a small opening into the intestine. Cooper (1920) describes these cavities in the suckers he examined from Douglas Lake in Michigan. He also records finding the worms in the pyloric chamber of the stomach.

During the summers (1931 and 1932) 336 fish representing 20 species were examined for parasites. Of these thirteen species were found to be infected. The thirteen species parasitized showed an infection of 49 per cent. Seven species which showed no infestation were *Esox vermiculatus, L. megalotis, L. humilis, Percina caprodes, Moxostoma aureolum, Stizostedion vitreum, Lepisosteus osseus.* Including all the species examined eight families of fish are represented: Amiatidae, Catostomidae, Centrarchidae, Cyprinidae, Esocidae, Percidae, Lepisosteidae, and Siluridae. Essex and Hunter (1927) in a study of fish parasites in the central states made collections from eight streams and seven lakes at various seasons of the year from August, 1923, to March, 1926, mak-

ing the most complete records in summer months, however. They examined representatives of fourteen families and forty different species of fresh water fish. In all they examined 652 individuals, thirty-nine per cent. of which were found to have one or more parasites. One reason for this relatively low percentage as explained by Essex and Hunter is that some species of fish are relatively free from parasites while others are heavily infected with several species. This was found to be true of the St. Joseph River fish. That is, certain species of fish are highly resistant to many kinds of parasites, others are susceptible to a great variety of parasitic infestation, while still others as the European carp are susceptible to one or two species of parasites only. Since this fish is by far the most common in the St. Joseph River I had the opportunity to examine 83 individuals; forty-one of these were infected with the same species of cestodarian while only four were parasitized with an acanthocephalan species. Essex and Hunter examined 26 carp, finding four with Acanthocephala and one with nematodes. According to Forbes and Richardson (1908) the European carp, which is native in China, was introduced into Europe about 1227 and first successfully introduced in the United States in 1877 when R. Hessel of the U. S. Fish Commission brought 345 carp to Washington, D. C., cultured them, and in 1879 young were distributed to more than 300 persons in 25 States and territories. These young fish were free from the European parasites of their ancestors. Although more mirror and scaleless varieties were introduced these appear less hardy in this country and the regularly scaled form predominates. From the large number infected with a cestodarian worm, it seems that this parasite has become thoroughly adjusted to its carp host in the St. Joseph River although the carp are almost entirely immune to any other parasite in this river.

It is interesting to note from the table showing fish infection in the St. Joseph River the comparative abundance of different classes of helminths: three species of Cestodaria, three species of Cestoda, five species of Trematoda, three species of Nematoda and one species of Acanthocephala. Among the nine species of fish infected 36 per cent. harbored

TABLE A

TABLE OF FISH INFECTION IN ST. JOSEPH RIVER IN SUMMERS OF 1931-1932

Host	Locality	No. of fish examined	No. of fish infected	Seat of infection	Ave. No. parasites per fish	Kind of Parasite	Date
Perca	mouth of St. Joe. R.			liver	4	*Trianophorus* sp.	1931
flavescens (yellow perch)	mouth of St. Joe. R.	110	20	liver	5	*Proteocephalus* sp.	
Cyprinus carpio (European carp)	Berrien Springs Niles St. Joseph	24	6	stom. and int.	6	cestodarian	1931
	Berrien Springs St. Joseph		4	viscera	3	*Pomphorhynchus bulbocoli* Linkins	
	South B. Niles St. Mary's College	59	35	stom.	8	cestodarian	1932
Catostomus	Niles	4	3	1. int.	22	*Pomphorhynchus bulbocoli* Link	
commersoni	Niles		3	1. int.	3	cestodarian	1931
(common sucker)	Niles	23	19	int.	32	*Pomphorhynchus bulbocoli* Link	1932
	Niles		8	sm. int.	9	*Glaridacris catostomi* Cooper	
	St. Joseph		4	stom. esoph.	6	*Azygia sp.*	
Amia calva (bowfin)	St. Joseph	5	1	int. stom.	159	*Microphallus opacus* Ward	1931
	St. Joseph		2	1. int.	6	nematode (unidentified)	
	St. Joseph		2	sm. int.	11	cestode (unidentified)	
	St. Joseph		1	int.	38	nematode (unidentified)	1931
Ambloplites	Berrien Springs	8	2	1 and ht.	75	*Neascus* sp. encysted	
rupestris (rock bass)	S. Bend		1	int.	1	nematode (unidentified)	1932
Ameiurus melas (bull head)	St. Joseph	2	1	stom.	2	*Pomphorhynchus bulbocoli* Link.	1931
Chaenobrittus gulosus (Warmouth bass)	St. Joseph	2	1	1 and ht.	12	*Neascus* sp. metacercaria cysts	
Micropterus	S. Bend	3	1	flesh near surface	6	trematode cysts (Holostomidae)	1932
dolomieu (small mouth bass)	S. Bend		2	flesh along back	29	trematode cysts (Holostomidae)	
Esox lucius (pickerel)	Niles	1	1	sm. int.	1	*Proteocephalus* sp.	1932

Total Number of Fish Examined from the River in 1931-1932: 315
Total Percentage of Fish Infected from River in 1931-1932: 35
Complete data secured only for the 241 specimens listed above.

Trematoda, 10 per cent. Cestoda, 19 per cent. Acanthocephala, 13 per cent. Nematoda, and 13 per cent. Cestodaria. This shows that trematodes are the internal parasites most frequently found in St. Joseph River fish. The highest individual infection per fish was due to the trematode *Microphallus opacus* parasitic in *Amia calva*. This parasite has also been recorded in catfish, perch, bass and frogs in North America.

According to Essex and Hunter (1927), Hunter (1927) and Hunter (1928) the Cestodaria are limited in distribution to the Catostomidae; however, my records show that a large percentage of the European carp (Cyprinidae) harbor a cestodarian parasite.*

COMPARISON OF INFECTION OF RIVER FISH WITH LAKE FISH

The following is a table showing the classes and numbers of parasites from six species of fish taken from three small lakes in south western Michigan which I examined.

TABLE B

Species	Number Examined	No. fish parasitized	Trematoda	Cestodaria	Cestoda	Nematoda	Acanthocephala	Locality
Micropterus salmoides	1	1	50				10	
Ameiurus melas	2	2			1			
Ameiurus natalis	1	1			14			Rush Lake
Lepomis symmetricus	8	8			34			
Ameiurus melas	1	1	1					Smith Lake
Micropterus salmoides	1	1			27			
Amia calva	4	2	66		1			
Lepomis pallidus	1	1	50					Lake La Grange
Micropterus salmoides	1	1	55				10	

Twenty-one fishes were examined from these lakes during the summer of 1931 which showed an infection of 90.4 per cent. Three hundred fifteen individuals from the St. Joseph River were examined. Thirty-five per cent. of these individuals were infected.

* In a recent letter from Dr. Hunter, he states that this cestodarian is probably identical with a new species which he is describing from the European carp, *Cyprinus carpio*, in Ohio.

COMPARISON OF DATA WITH OTHER SURVEYS

Table C gives a comparison of fish infection with the data of Ward (1912) and Essex and Hunter (1927). Ward's data represent records made over ten or twelve years. These data taken as a whole give some idea as to the helminth fauna of fresh water fishes in North America. All three sets of figures show that Acanthocephala are most frequently found in parasitic fauna of fresh water fishes.

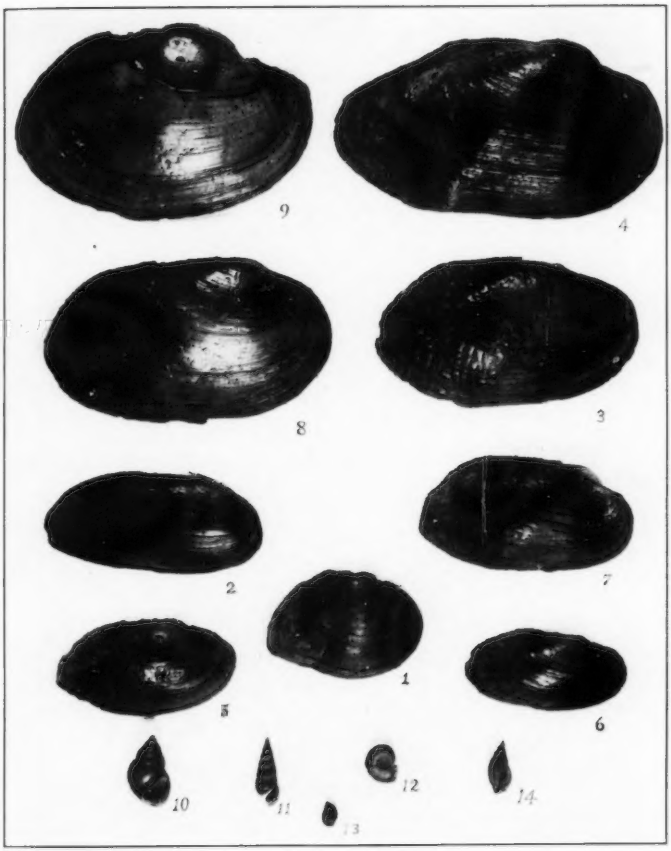
TABLE C

Comparison of data from Ward and Essex and Hunter with those of present paper.

Hosts	Examined No.			Parasitized No.			Trematodes			Cestodes			Nematodes			Acantho-cephala		
	W	EH	D	W	EH	D	W	EH	D	W	EH	D	W	EH	D	W	EH	D
Amiatidae- *Amia calva* ..	32	13	9	27	10	6	16	4	183	21	10	23	18	4	13	8	1	0
Catastomidae **Catostomus commersomii* .	6	3	27	6	1	19	0	0	0	0	0	88	0	0	0	0	0	763
Cyprinidae- **Cyprinus carpio*	10	26	83	8	5	35	0	0	0	0	0	219	0	0	0	0	0	16
Percidae- *Perca flavescens*	40	8	110	39	8	20	5	0	0	31	8	43	19	2	0	6	0	0
Centrarchidae- *Ambloplites rupestris*	31	41	4	31	35	2	75	0	75	13	8	43	19	2	0	6	0	0
Chaenobrittus gulosus	..	..	2	..	..	1	..	..	12	..	..	0	..	..	0	..	..	0
Micropterus dolomieu	45	8	3	44	8	2	251	0	63	146	7	0	18	1	0	703	5	10
Micropterus salmoides.....	2	28	2	2	25	2	123	1	55	3	0	27	0	6	0	23	20	
Lepomis pallidus.....	7	12	2	6	5	2	190	3	0	0	0	17	110	0	0	28	3	0
Lepomis symmetricus...	..	..	9	..	..	9	..	..	50	..	..	34	..	..	0	..	..	0
Siluridae- *Ameiurus melas*.....	1	9	5	1	9	4	1	9	1	0	6	1	0	0	0	0	7	1
Ameiurus natalis.....	1	..	1	1	..	1	17	..	0	1	..	14	0	..	0	1	..	0
Esocidae- *Esox lucius*	3	8	1	3	6	1	8	0	0	8	5	1	0	3	0	8	3	0

Note: *Cestodaria are included under cestodes. W=Ward (1912: EH=Essex and Hunter (1927); D=Dolley (present paper).

PLATE II



1. *Fussconaia flava* (Ref.)
2. *Elliptio dilatatus delicatus* (Simpson)
3. *Lasmigona costata* Raf.
4. *Anodonta grandis* Say.
5. *Anodontoides ferussacianus subcylindraceus* (Lea)
6. *Alasmidonta marginata* Say.
7. *Strophitus rugosus* (Swainson)
8. *Actinonaias carinata* (Barnes)
9. *Lampsilis ventricosa* (Barnes)
10. *Campeloma rufum* (Haldeman) variety
11. *Pleurocera acuta* Raf.
12. *Helisoma trivolvis* (Say)
13. *Physa gyrina* Say.
14. *Stagnicola palustria elodes* (Say)

SUMMARY

1. A study of the St. Joseph River between Mishawaka, Indiana, and Benton Harbor, Michigan, show this portion of the stream to be polluted by wastes from the cities of South Bend and Mishawaka.

2. The sluggish nature of the stream together with an insufficient volume of water to care for proper oxidation and natural purification make the river between Mishawaka, Indiana, and Niles, Michigan, unsuitable to a variety of fish life or any other fresh water life excepting pollution-tolerant forms.

3. The following facts indicate the polluted nature of the river between South Bend, Indiana, and Niles, Michigan:

   (a) The offensive odors of putrefaction between South Bend and Niles.

   (b) Insufficient dissolved oxygen between South Bend and Niles to support a variety of fish life.

   (c) The very high *B. coli* count immediately below South Bend.

   (d) The relative absence of snails, bivalves and decapod Crustacea between South Bend and Bertrand.

   (e) The occurrence of the pollution-tolerant organisms, Saprolegnia, Epistylis, Euglena, Paramecium, Aeolosoma, and Chaetogaster in the plankton between South Bend and Niles.

   (f) The predominance of carp over any other species of fish in the river.

4. Of 336 fish representing 20 species from the St. Joseph River and three small lakes in South Central Michigan examined for parasites, 13 species were infected.

5. Nine species of St. Joseph River fishes were infected with one or more parasites.

6. Cestodaria, which are typically parasites of the Catastomidae, are here recorded from the Cyprinidae of the St. Joseph River.

7. Data obtained show that Acanthocephala are the most frequent helminths of fresh water fishes.

8. The finding of the first intermediate host of *D. latum* in relative abundance during winter months increases the probability that the St. Joseph River may serve as a means for the further dissemination of this tapeworm in Indiana and Michigan.

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SOME LIZARDS FROM THE GREAT BASIN OF THE WEST AND ADJACENT AREAS, WITH COMMENTS ON THE STATUS OF VARIOUS FORMS.

CHARLES E. BURT

During August, 1932, while I was enroute from Kansas to visit museums in California in connection with my studies of North American herpetology, I took the opportunity to collect a series of lizards and to make various ecological annotations about them. In addition to this fundament, certain records from specimens kindly sent to me by those excellent collectors, Lewis T. Barry, Charles M. Bogert, and Lorenzo H. Cook, are included in the following pages. Likewise, several western records gleaned from the collection of Kansas State College, through the kind permission of Dr. Robert K. Nabours, are presented here.

This present manuscript has been read by Mr. L. M. Klauber, who has kindly made a number of helpful comments upon it.

The nomenclature adopted below is in accordance with that being used in my "Key to the Lizards of the United States and Canada," which is now nearing completion. Usually the choice of names has been in accordance with the latest research, but in a number of cases existing stands are modified along progressive lines, dictated to me by my study of types and other specimens at the United States National Museum, and by a survey of the literature. In most cases, changes proposed in relatively short generalized discussions here, will be elaborated in greater detail in subsequent publications. Perhaps, the greatest systematic alteration lies in the treatment of the lizards of the *undulatus* group of the genus *Sceloporus*, which I have been forced to study in considerable detail.

In some respects, the ecological part of the present contribution is an elaboration of the lizard section of the previous field study by Burt and Burt entitled "Field Notes and Locality Records on a Collection of Amphibians and Reptiles, Chiefly from the Western Half of the United States" (1929),

although several different forms are mentioned here and a new territory has been traversed. The systematic account follows.

LIST OF SPECIES

Dipso-saurus dorsalis dorsalis (Baird and Girard)

One of these lizards was taken at Palm Springs, Riverside County, California, by Charles M. Bogert in 1930.

Crotaphytus collaris (Say)

A fine series of collared lizards was secured from rocky places in the Great Basin, where the species appears as a typical form.

A young individual, having a body length of 43 millimeters and a tail measuring 85, was taken in Coconino County, Arizona, on August 25; one, with a body length of 44 and a tail length of 71, was secured in Mohave County, Arizona, on August 24; and another, with a body length of 43 and a tail length of 76, was collected in Churchill County, Nevada, on August 13.

The reports of the occurrence of the collared lizards at hand are listed below.

Arizona: 4 miles west of Cameron, 11 miles west of Cameron, 14 miles west of Cameron, 16 miles west of Cameron, 19 miles west of Cameron, and 3 miles south of Canyon Diablo, in Coconino County; 3 miles west of Roosevelt Dam, Gila County (by Keith Corp); 7 miles west of Drake, 7 miles northeast of Goldroad, 1 mile northeast of Peach Springs, and 4 miles north of Valentine, in Mohave County; and 6 miles northwest of Seligman, Yavapai County.

Colorado: 10 miles southwest of Delta, in Montrose County.

Nevada: 7 miles east of Frenchman, and 3 miles west of Frenchman, in Churchill County; 7 miles east of Vista, Storey County; and 1 mile west of Derby, Washoe County.

New Mexico: 7 miles southeast of Laguna, and 5 miles northwest of Rio Puerco, in Valencia County.

Crotaphytus wislizenii (Baird and Girard)

In Arizona, in the gravel of the desert among yucca and low shrubs, 7 miles northwest of Hackberry, Mohave County, a young leopard lizard (with a body length of 60 millimeters and a tail length of 132) was found on August 24.

In 1930, a specimen taken in the Antelope Valley at Lovejoy Springs, in Los Angeles County, California, was received from Charles M. Bogert.

In Nevada, specimens were secured on the flat hardpan desert 7 miles west of Frenchman, and 2 miles east of Sand Spring, in Churchill County, on August 13.

In Utah, among small rocks, greasewood, and sand in the desolate desert country west of the Confusion Range, 15 miles northeast of Simmonson's Ranch, in western Millard County, one of these lizards was found to be foraging about on the early morning of August 12.

Sauromalus obesus (Baird)

A chuck-walla was secured 5 miles east of Wickenburg, Maricopa County, Arizona, by one of my students, Keith Corp, on June 31, 1932, where it was attempting concealment in the rock crevices of canyon boulders. Individuals of this species are sly and usually hide in rock crevices in such a way that their removal from this shelter by ordinary methods is practically impossible.

Callisaurus draconoides ventralis (Hallowell)

Homalosaurus ventralis Hallowell, Proc. Acad. Nat. Sci. Phila., Vol. 6, 1852, p. 179 (type locality, New Mexico west of the Rio Grande).

Callisaurus draconoides ventralis Cope, Ann. Rept. U. S. Nat. Mus. for 1898, 1900, p. 272, fig. 25.

Callisaurus ventralis gabbii Cope, Ann. Rept. U. S. Nat. Mus. for 1898, 1900, p. 272 (type locality, Northern Lower California).

Callisaurus ventralis myurus Richardson, Proc. U. S. Nat. Mus., Vol. 48, 1915, p. 408 (type locality, Pyramid Lake Indian Agency, Nevada).

The average differences by which the alleged United States sub-species in this assemblage have been separated are insufficient to warrant their further recognition, and after an examination of considerable material, I believe that it is un-

likely that better ones will be found. The unconvincing nature of these criteria should become evident at once to those who examine the summaries of Van Denburgh (1922) and Schmidt (1922) with specimens of these lizards from various localities available for comparison and attempted identification.

The probable correctness of Linsdale's assignment (1932) of *ventralis* and its described allies to subspecific status with the previously described *draconoides* is at once apparent, so this action is followed here.

This is a characteristic lizard of the arid sections of the west, where it occurs most commonly in level rocky or gravelly areas, and less frequently in sandy formations. Like the jackrabbit, *Callisaurus* is specialized for speed, and naturally this talent is utilized to better advantage in flat country than in decidedly rough or mountainous terrain. In typical habitats, yucca, greasewood, and sage often form the dominant vegetation. Here, given individuals may be active throughout the daylight hours, but a larger and larger proportion of the population appears to seek seclusion as the day lengthens (and the temperature rises). One example was scampering about after sunset on August 23 in San Bernardino County, California.

Callisaurus draconoides ventralis was found to be unusually abundant in a rock strewn valley east of Sand Spring, Nevada, on the morning of August 13. Here the flattened surface of a newly constructed and very black oiled pavement seemed to appeal to the lizards as a fine place to sun themselves, for they were congregated on it in numbers. It was soon found that several freshly killed examples had been struck by passing automobiles and that a number of others had suffered a like fate at a slightly earlier time. Living individuals were spotted at once on this black background because of the distinct contrast allowed by the whiteness of their bodies. Some of these were collected but many raced away to safety, some escaping into holes at the foot of desert bushes, and others running too swiftly and too far to be followed. A young specimen from this locality (U.S.N.M. No. 86952) has a body length of 32 millimeters and a tail length of 44, and

one taken on August 24 near Hackberry, Arizona, is of exactly the same proportions.

Present locality records for *ventralis* are listed below.

Arizona: 2 miles west of Hancock, and 1 mile northwest of Hackberry, in Mohave County.

California: Lovejoy Springs, Los Angeles County (based on a specimen collected by Charles M. Bogert); and 7 miles southwest of Essex, and at Siberia, San Bernardino County.

Nevada: 3 miles west of Frenchman, 1 mile southeast of Salt Wells, 2 miles east of Sand Spring, and 3 miles east of Sand Spring, in Churchill County.

Holbrookia maculata maculata (Girard)

Holbrookia maculata Girard, Proc. Amer. Assoc. Adv. Sci., Vol. 4, 1851, p. 201 (type locality, opposite Grand Island, Platte River, Nebraska).

Holbrookia approximans Baird, Proc. Acad. Nat. Sci. Phila., 1858, p. 253 (type locality, "Lower Rio Grande").

Holbrookia maculata approximans Cope, Ann. Rept. U. S. Nat. Mus. for 1898, 1900, p. 297.

Holbrookia maculata maculata Cope, Ann. Rept. U. S. Nat. Mus. for 1898, 1900, p. 293, fig. 33.

Van Denburgh (1924) is followed in regarding a number of the described subspecies of this lizard (*campi, flavilenta, pulchra,* and possibly *elegans*) as synonyms. Moreover, no positive diagnosis of the Sonoran *approximans* from the Middle West *maculata* can apparently be maintained. The distinction of the exhibition of under or over 50 per cent of tail length fails in both sexes in various areas, sometimes extensively; and the failure of this point even throws the Texan *propinqua* into this same complex, although it can apparently be recognized as a southeastern subspecies of *maculata* (on average grounds at least). According to a recent communication from Lewis T. Barry, convincing identity is maintained in these lizards in Colorado from both sides of the Continental Divide, even after a detailed statistical comparison of various features. This agrees with by own generalized findings.

A specimen of *Holbrookia maculata maculata* was taken from the rocky desert 2 miles west of Cameron, Coconino

County, Arizona, on August 25; and Lewis T. Barry has forwarded an example that was collected on May 24, 1932, in the Mancos River Valley near the New Mexico state line in Montezuma County, Colorado.

Uta graciosa (Hallowell)

These Utas were found living in and on large upright tree yuccas 2 miles west of Hancock, Mohave County, Arizona, where they were well protected. The average yucca stalk had green leaves at the top, followed by fringes of dead leaves below, and while a number of specimens of *graciosa* were heard or seen as they rustled through these dead leaves, only one was finally captured.

Uta levis Stejneger

This sly, and rather rare, little lizard is a characteristic inhabitant of the largest boulders in mountainous districts where large outcroppings or deposits of rocks occur. Individuals usually forage about for food or sun themselves near convenient cracks which provide shelter and offer ample protection from large enemies when danger threatens. No boulder Utas were observed on small rocks. Three specimens were secured in a boulder area 1 mile southeast of Castlegate, Carbon, Utah, on August 11.

Uta stansburiana Baird and Girard

Uta stansburiana Baird and Girard, in Stansbury's Expl. Surv. Valley Great Salt Lake, 1852, p. 345, pl. 5, figs. 4-6 (type locality, Salt Lake Valley).

Uta elegans Yarrow, Proc. U. S. Nat. Mus., Vol. 5, 1882, p. 443 (type locality, La Paz, Lower California).

Uta stansburiana hesperis Richardson, Proc. U. S. Nat. Mus., Vol. 48, 1915, p. 415 (type locality, Arroyo Seco Canyon, near Pasadena, Los Angeles County, California).—Stejneger and Barbour, Check List N. Amer. Amph. Reptil., Ed. 2, 1923, p. 53.

Uta stansburiana stejnegeri Schmidt, Amer. Mus. Novitates, No. 15, 1921, p. 1 (type locality, Mouth of Dry Canyon, Alamogordo, Otero County, New Mexico).—Stejneger and Barbour, Check List of N. Amer. Amph. Reptil., Ed. 2, 1923, p. 53.

Uta stansburiana stansburiana Stejneger and Barbour, Check List. N. Amer. Amph. Reptil., Ed. 2, 1923, p. 53.

As suggested by Burt and Burt (1929, p. 453) the subspecies described from California by Richardson (1915, p. 415) as *Uta stansburiana hesperis* does not seem to be separable from true *stansburiana*. In fact, *Uta stansburiana* appears to be composed of a highly variable wide-ranging population not dissimilar to *Cnemidophorus tessellatus tessellatus* of the same general range and it seems very unlikely that satisfactory geographical races for either of these forms will be established in the United States.

The difficulty involved in an attempt to recognize the described subspecies of *Uta stansburiana* by name (i. e., by character) was clearly conceived by Linsdale (1932, p. 363), who is followed here in recognizing only the stem form *stansburiana*.

The habitat of this species is typically that of the great deserts and semi-deserts of the west, where it occurs in both open and sparsely wooded tracts; on hardpan, on gravel, and on sand; about or on rocks; in holes in the ground or even in fallen yucca trunks. The dominant vegetation varies in these places, being buffalo grass in certain hardpan tracts; yucca, greasewood, and sagebrush in the open spaces; and relatively luxuriant sage and other desert shrubs at the edge of low open woods such as those that are found near various streamlets. Individuals are usually somewhat darker than the average in the black lava beds of Nevada, where such coloration has a definite protective value.

Uta stansburiana is abundant in favorable habitats, appearing from sheltered nooks from dawn to dusk, and on the desert in the Valley of the Colorado River near Needles, in California, several examples were found scampering through sparse vegetation in the warm hours following sunset on August 23. The maximum activity of the species seems to be reached during the forenoon, when several individuals may be seen at once in many places. Several of these little creatures were scared into holes in semi-sandy districts, where they could often be dug from the burrows, which branch in most cases and sometimes extend for considerable distances.

Ruthven and Stuart (1932) have recently recorded some notes on the period of post-depositional development in sev-

eral common lizards of Utah and Nevada. According to their data on *Uta stansburiana*, the females deposit their eggs before the middle of July. After a period of incubation, the eggs hatch, and the young begin to appear in late July or August. The present collection was made entirely in August, so it did not include females with mature eggs in the coelom. Young were taken in five states as follows:

State	Length from snout to anus (mm.)	Date
Arizona	28–30	August 24
Arizona	27	August 25
California	28	August 18
Colorado	27	August 10
Nevada	20	August 12
Utah	25	August 11

The present locality records for *Uta stansburiana* are listed below.

Arizona: 11 miles west of Cameron, 16 miles west of Cameron, and 19 miles west of Cameron, in Coconino County; and 7 miles west of Drake, 7 miles northeast of Goldroad, 1 mile northeast of Hackberry, and 2 miles west of Hancock, Mohave County.

California: 15 miles south of Bakersfield, edge of Grapevine Creek at Grapevine, 2 miles south of Grapevine, and 2 miles south of Wheeler Ridge, in Kern County; 1 mile southwest of Perris, and 5 miles southwest of Perris, Riverside County; 3 miles north of Cajon, 7 miles southwest of Essex, and on the Mohave River banks 1 mile south of Oro Grande, San Bernardino County; and Silver Strand near Coronado Beach, and 1 mile north of the Sweetwater Reservoir, in San Diego County. The last two reports are based on specimens collected by Lorenzo H. Cook.

Colorado: 13 miles southwest of Delta, in Montrose County.

Nevada: 7 miles east of Frenchman, and 2 miles east of Sand Spring, in Churchill County; 12 miles south of Eureka, Eureka County; and 4 miles northeast of Baker, 3 miles

northwest of Baker, and 8 miles west of Illipah, White Pine County.

Utah: 5 miles southeast of Mounds, and 4 miles northwest of Woodside, Emery County; 2 miles east of Simmonson's Ranch, 4 miles east of Simmonson's Ranch, 10 miles east of Simmonson's Ranch, 15 miles northeast of Simmonson's Ranch, and 2 miles south of Simmonson's Ranch, western Millard County (all in the valley west of the Confusion Range); 23 miles southeast of Smithville, in the valley between the Confusion and the House ranges, also in Millard County; and 3 miles west of Elberta in the valley near the East Tintic Mountains, Utah County.

Sceloporus graciosus graciosus (Baird and Girard)

This typical Great Basin subspecies has the distinct striping that is so characteristic of *S. undulatus consobrinus* of adjacent areas, from which it differs on the average, in having smoother, less keeled scales on the body and in having the blue throat patches diffused or indistinct, even in adult males. There are also other differences, such as the occurrence of an increase in the number of dorsal scales in *graciosus*.

Perhaps the form that is most likely to be confused with *graciosus* is *S. undulatus elongatus* of the same general range, which happens to have about the same number of dorsal scales, as well as a confusing atavistic or orthogenetic tendency to develop recognizable light stripes on the sides when they are typically (supposed to be) absent. The stripes of *graciosus* are very distinct in typical examples, but in some cases they become reduced or indistinct so that aberrant representatives of both forms may show a merging in the type of coloration that they assume.

In this case the presence of diffused blue or gray throat patches in adults (especially males) is still diagnostic of *graciosus*, and the presence of concentrated or distinct throat patches is typical of adult examples of *elongatus*. But even here there is difficulty, since this distinction tends to break down, or to become uncertain in its application, in the treatment of certain females and of the young.

Next, one may compare the scalation of the two subspecies.

Here we find the same difference between *graciosus* and *elongatus* as that indicated above between *graciosus* and *consobrinus*, namely an average weaker keeling or smoother scutellation in *graciosus*. This fine distinction is most evident on the upper edge of the back part of the thigh and at the sides of the body where keeled dorsal scales grade over into smooth ventral ones.

Both graciosus and *elongatus* may be present in the same habitat, often being found together in areas strewn with rocks and boulders, such as those that occur at or near the base of western mountains. There is some indication, from my experiences, that *graciosus* is a little more plastic in regard to its ability to become adapted to life in sandy areas and, in typical boulder environments at the center of the range, *elongatus* tends to occur in the greatest abundance.

The specimens of *graciosus* at hand are listed below.

Colorado: 2 miles northwest of the intersection of highway No. 666 and the New Mexico state line, Mancos River Valley just north of the New Mexico state line, and Spruce Tree Canyon in the Mesa Verde National Park, in Montezuma County (from Lewis T. Barry).

Utah: 1 mile southeast of Castlegate, Carbon County; 9 miles northwest of Woodside, Emery County; 2 miles south of Simmonson's Ranch, western Millard County; and 4 miles west of Elberta, and 6 miles east of Thistle, Utah County.

Sceloporus magister magister (Hallowell)

Linsdale (1932) is followed in giving this form subspecific status with *rufidorsum* and *zosteromus*.

The present Arizona examples of *magister* were found in the vicinity of boulders, but those in Nevada were more arboreal, one individual being located on a fence post and another in a large clump of greasewood bushes that were growing on a hillock of fine sand. These records may be listed as follows:

Arizona: 11 miles west of Cameron, and 16 miles west of Cameron, Coconino County.

Nevada: 4 miles west of Fallon, and at Sand Spring, Churchill County.

Sceloporus orcutti Stejneger

This wary, large spiny swift was found in Riverside County, California, both before and after sunrise on August 23 as it foraged over large boulders or sunned itself from them. Frightened individuals lodged in cracks and were often extremely hard to capture. Specimens were obtained as follows: 3 miles north of Elsinore, 2 miles south of Elsinore, 1 mile southwest of Perris, and 4 miles southeast of Riverside.

Sceloporus undulatus bi-seriatus (Hallowell)

In my repeated studies of specimens of *Sceloporus*, I have been struck with the marked similarity of certain eastern and western forms, although I have always separated them on geographical grounds without taking the trouble to differentiate them on a morphological basis. But in the preparation of a key to the forms inhabiting the United States as a whole, I am unable to evade the issue to a further extent.

In 1900, Cope placed the eastern *undulatus* and the western *occidentalis-bi-seriatus* complex together on the basis of the striking identity presented by their coloration and other morphological features, and after a careful analysis of the problem I see no very practical reason for not following his decision; yet, on purely theoretical grounds, the two geographically isolated groups had best be kept apart in the hope that future study may reveal some overlooked, significant differences between the two populations. All diagnostic criteria that have been advanced in the past appear to be worthless.

From a broad zoogeographical viewpoint, the representative stock of the *undulatus* complex needs to be studied in great detail in Mexico. It is possible that, in this area, eastern rudiments of *undulatus* may be found to become contiguous in their distribution with western adumbrations of the *occidentalis-bi-seriatus* stock. In such a case, there might be evident grounds for considering *undulatus* an intact subspecific unit, which in this manner present both unified characters and a continuous (although phenomenal) dispersal. But still other complications are in view.

In the West, *occidentalis* and *bi-seriatus* (and *taylori*) appear to be good subspecies on the basis of the characters employed for their separation by Van Denburgh (1922), but in the East these characters occur indiscriminately in the general population of *undulatus*.

In many zoological stocks, considerable differentiation from both eastern and Californian forms has been brought about by forces operating in the intervening Great Plains and Great Basin area of the Middle West. Such appears to be true of the spiny swifts of the *undulatus* complex. In fact at least two subspecific units are in evidence here. These are *consobrinus* of the Great Plains area (and most of New Mexico and Azizona), and *elongatus* of the Great Basin area. Approximate intergrades or intermediates between *consobrinus* and *elongatus* have been described as *tristichus* from Taos, in north central New Mexico.

After an examination of the co-types of *thayerii*, I have reached the conclusion that the name must be regarded as a synonym of that of *undulatus* (as found in the East from Texas to the Atlantic seaboard), for *thayerii* was based on specimens from eastern Texas which show the characters of the eastern subspecies, contrary to the opinion of Jones (1926). Therefore the name *consobrinus* must be retained for the Middle West subspecies which Jones called *thayerii*. Full details as to this proposed taxonomic change are included in my forthcoming study entitled "A Contribution to the Knowledge of the Amphibians and Reptiles of Texas."

Evidence of the intergradation of all forms mentioned above is at hand. Therefore, *Sceloporus undulatus* is considered to be divisible into a series of subspecies which extend across the continent from the Atlantic to the Pacific. To these may be added *woodi* of southern Florida, which may be separated from typical *undulatus* by a differential diagnosis based on several average contrasts in characters.

Under the existing circumstances the primary division of these subspecies must be made as follows:

> "Occidental forms, Pacific Coast and Great Basin of the West; usually over 20 subdigital lamellae under the longest toe of the hind foot; colorational and structural fea-

tures highly variable, often practically identical with eastern forms (including most of Colorado and Wyoming and the northern border of New Mexico and Arizona).

Oriental forms, Atlantic and Gulf coasts and the Mississippi Valley, north into Canada; sometimes under 20 subdigital lamellae (including North Dakota south to Texas, then west to Arizona; also, eastern Wyoming)."

With this more or less arbitrary geographical separation of the subspecies of *undulatus* completed, it is relatively easy to separate the eastern and western components into their respective places, although much difficulty is still encountered here. The affinities of each of the western subspecies will be discussed below under the forms concerned. Typically, all forms occupy adjacent habitats to those of their closest phylogenetic associates.

The present discussion lies under the head of *Sceloporus undulatus bi-seriatus*, which has been classified recently as a subspecies of *S. occidentalis*. On the borders of its range *biseriatus* meets or approaches the areas occupied by *occidentalis*, *elongatus*, and *consobrinus;* and within the range proper, *taylori* has evolved. The intergradation of *bi-seriatus* with *occidentalis* in the northern half of California is well known, and the relationship of *bi-seriatus* and *taylori* was made clear by Camp (1916), when he described the latter form. Apparently the ranges of *bi-seriatus* and *consobrinus* are well separated along the California-Arizona border, which is formed by the Valley of the Colorado River, and no evidence of the direct intergradation of these two forms is at hand. This leaves only the relationship of *bi-seriatus* and *elongatus* to be discussed.

According to Van Denburgh (1922) the scales from the occiput to the base of the tail are from 35 to 44 in *bi-seriatus* and from 40 to 53 in *elongatus*. This is the most constant difference between the two populations and, as such, it must be employed in their diagnosis. If we arbitrarily regard all of these lizards having 42 or less than 42 scales from the occiput to the base of the tail as *bi-seriatus* and those having more than this number as *elongatus*, a zone of intergradation

between the two forms becomes evident in eastern Nevada and western Utah where the ranges of the two subspecies meet and overlap. This phenomenon is noted in the present specimens from White Pine County, Nevada, and an intergrade with a count of 43 was collected in Eureka County to the west. Throat patches of intergrades in Nevada may be united as in *bi-seriatus* instead of separated as in *elongatus* of the west and south.

In California, a young *bi-seriatus* specimen with a body length of 30 millimeters was taken in Kern County on August 18; and others with body lengths ranging from 25 to 48 were secured in Mariposa County on August 17. Both young and adults were found on boulders or rocks, in woods, or on isolated logs.

The specimens of *bi-seriatus* in the present collection are listed below.

California: at Grapevine, Kern County; at Buckmeadows, 1 mile north of Chinquapin, 1 mile northwest of the Gentry Ranger Station of Yosemite National Park, and just below Inspiration Point on the Wawona Road at 5000 feet in the Yosemite National Park, all in Mariposa County; 3 miles west of Truckee, Nevada County; 1 mile south of Oro Grande, San Bernardino County; Adobe Falls, and Balboa Park, San Diego County (by Lorenzo H. Cook); 11 miles northeast of Hobart Mills on a rock near the Truckee River, in Sierra County; and 1 mile west of Groveland, Tuolumne County.

Nevada: on rocks above the Truckee River, 1 mile southwest of Verdi, Washoe County; and 8 miles west of Illipah, White Pine County (38 scales from the occiput to the base of the tail).

Sceloporus undulatus consobrinus (Baird and Girard)

This subspecies occupies habitats adjacent to those of *undulatus*, *elongatus*, and *bi-seriatus*. Its intergradations with *undulatus* has been established and, so far as we know, it does not meet *bi-seriatus* in natural habitats. This leaves only the relationship of *consobrinus* and *elongatus* open to discussion.

Typically, *consobrinus* has very distinct stripes on the

sides, while *elongatus* has very obsolete ones or none at all. However, considerable reversion or orthogenesis, as the respective cases may be, occurs in the populations of both subspecies in this regard. A specimen from near Manuelito, McKinley County, New Mexico, is approximately an intergrade between the two forms, with the lateral stripes more indistinct than in typical *consobrinus* but more distinct than in typical *elongatus*. Specimens from Montezuma County, Colorado, some distance to the north show every transition from no stripes to faint stripes on the sides. Specimens from near Chambers, Apache County, Arizona, are also of the intermediate (or *tristichus*) type of development.

According to Van Denburgh, *consobrinus* has from 36 to 47 scales from the occiput to the base of the tail, and *elongatus* from 40 to 53. Intergradation occurs in this feature as in others. Further evidence of intergradation between the two subspecies should be obtained by a study of their stocks in northern New Mexico and Arizona. No suggestion of intergradation has been obtained from my examination of these lizards in eastern Colorado (and I have seen well differentiated *elongatus* that were collected by Lewis T. Barry in the southeastern corner of the state) or Wyoming.

In Arizona, specimens of *consobrinus* were taken mostly in sparse woods, where they tend to be somewhat arboreal, sometimes climbing dwarf cedar or pine trees when pursued. Some examples were also taken on rocks, as were all of the individuals from New Mexico.

The specimens secured are listed below.

Arizona: 19 miles west of Cameron, Concord Basin Auto Camp about 10 miles southeast of Grandview Point, 7 miles south of Navajo Point, 8 miles southeast of Navajo Point, 4 miles southeast of Winona, and 15 miles southeast of Woodside in Coconino National Forest, all in Coconino County; and 1 mile northeast of Peach Springs, Mohave County.

New Mexico: 4 miles southeast of Manuelito, McKinley County; Alamagordo, Otero County (Mus. Kan. St. Coll); and 1 mile southeast of Cubero, Valencia County.

Sceloporus undulatus elongatus (Stejneger)

The relationships of this subspecies, which intergrades with *bi-seriatus* and *consobrinus,* have been discussed above under those forms.

Specimens of *elongatus* taken on the black lava rocks of Nevada were often unusually dark in color. Adults were nearly always found on or very near to outcroppings of rock. Such was the case in Montrose County, Colorado, where rock cliffs and ledges lined the canyon of Roubideau Creek. The young, however, were found in sandy areas in the valley and several made their home near a cabin there. These particular young had a body length of from 26 to 29 millimeters and a tail length of from 38 to 44. They were found on August 10.

The present specimens of *elongatus* may be listed as follows:

Arizona: 3 miles southwest of Chambers, Apache County.

Colorado: Four Corners, Mancos River Valley just across the state line from New Mexico, and Soda Tip-off, in Montezuma County (by Lewis T. Barry); and 10 miles southwest of Delta, 12 miles southwest of Delta, and 13 miles southwest of Delta, in Montrose County.

Nevada: 5 miles west of Eureka, Eureka County; and 12 miles northwest of Hamilton, White Pine County. Both of these lizards have 43 scales from the occiput to the base of the tail.

Utah: 1 mile southeast of Castlegate, Carbon County (very abundant).

Sceloporus undulatus occidentalis (Baird and Girard)

This form was taken in California 2 miles southwest of Altamont, Alameda County; 1 mile southwest of Knights Ferry, Stanislaus County; and 4 miles east of Buckmeadows and 1 mile northwest of Buckmeadows, in Tuolumne County.

Phrynosoma coronatum blainvillii (Gray)

Linsdale (1932, p. 368) is followed in recognizing *blainvil-*

lii as a subspecies of *Phrynosoma coronatum*. A specimen from Adobe Falls, San Diego County, California, was received from Lorenzo H. Cook on April 2, 1931.

Phrynosoma douglassii hernandesi (Girard)

Tapaya hernandesi Girard, U. S. Expl. Exp., Herp., 1858, p. 395 (type locality, New Mexico).

Tapaya ornatissima Girard, U. S. Expl. Exp., Herp., 1858, p. 396 (type locality, mountainous region of New Mexico).

Phrynosoma douglassii hernandesi Cope, Ann. Rept. U. S. Nat. Mus. for 1898, 1900, p. 413, fig. 70.

Phrynosoma douglassii ornatissimum Cope, Ann. Rept. U. S. Nat. Mus. for 1898, 1900, p. 415, fig. 71.

As suggested by my previous statements (Burt, 1928, pp. 33-34; and Burt and Burt, 1929, p. 454), I have doubted the distinctness of *ornatissimum* and *hernandesi* from each other for a considerable time. Moreover, the unreliable nature of the presumed diagnostic features has been recognized by Van Denburgh (1922) and others. During the past summer numerous examples of this lizard were examined at various museums in connection with some of my contemplated publications and during this process the futility of satisfactorily re-diagnosing these two described subspecies became more and more evident. Therefore, I place them together here in full agreement with the action taken recently by Terron (1932).

The angle at which the occipital horns appear on the head of the adults is subjected to wide variation, which may be rather constant in isolated populations, here and there, but it is indiscriminately assorted in many others. Body spines are usually more highly developed, and the dorsal scales tend to be somewhat enlarged, in individuals living in the rockier habitats.

The present recognition of both *brevirostre* and *ornatum* seems unwarranted on the basis of the published distinctions of these forms from *hernandesi* and new diagnoses are much to be desired, if these names are to be kept out of the synonymy. In fact, it is only with the capitalization of a series of average trends in the Pacific Northwest, some of which are

admittedly obscure, that one is able to recognize *douglassii* as definitely distinct from *hernandesi*, but it appears that this can be accomplished. My study of these lizards is progressing, but still incomplete, and further details may be expected to appear later.

A young horned lizard taken at the base of a barren hillock amid gravel and tufts of grass 3 miles east of Delta, Delta County, Colorado, on August 9, had a body length of 26 millimeters and a tail that measured only 9. Adults were also secured in this habitat.

An adult from Estancia, Torrance County, New Mexico, was collected by Hobart M. Smith on August 5, 1931. It is now in the Museum of Kansas State College.

A second young individual was found in the sand at a greasewood area 9 miles northwest of Woodside, Emery County, Utah, on the sunny morning of August 11. Its measurements are: body 27, and tail 10.

Phrynosoma platyrhinos Girard

In Utah, this species was found foraging among greasewood clumps on the arid hardpan desert 2 miles east of Simmonson's Ranch, in western Millard County, on August 12.

Across the line in Nevada, and at the same date, examples were secured 4 miles northeast of Baker, and 3 miles northwest of Baker, in White Pine County. The back of one large individual was marked with many orange spots in life, and the hind toes were orange colored beneath.

Phrynosoma solare Gray

One of these fine horned lizards was collected on the sand of a canyon floor 5 miles east of Wickenburg, Maricopa County, Arizona, on June 31, 1932, by Keith Corp.

Gerrhonotus scincicauda webbii (Baird)

This alligator lizard was secured at Adobe Falls, San Diego County, California, by Lorenzo H. Cook on April 2, 1931.

Xantusia vigilis Baird

An Arizona representative of this sly little night lizard was found on August 24 in the semi-desert country 2 miles west of Hancock, Mohave County, Arizona. Here the lizard was located on the inside of a dead yucca plant of the tree variety, which was upright before it was torn to pieces. In this area the desert floor was composed of coarse sand and gravel.

Two of my personal counts across the middle of the back of this specimen, indicated that there were 38 or 39 longitudinal dorsal rows of granules, which fits the present form but is atypical of *Xantusia arizonae*, the species recently described from Yarnell, Yavapai County, Arizona, by Klauber (1931), who has prepared a synopsis of the genus. The example involved was sent to Mr. Klauber, who kindly offered the following comment on it in a letter dated February 7, 1933: "The *Xantusia* is undoubtedly *vigilis*, and it is the first (so far as I know) to be reported from Arizona. I made a comparison on three points and found in each case that your specimen is close to the upper limit of *vigilis* but quite a long way from *arizonae*. I took four counts of the scale rows across the back and got 41, 38, 40, and 38, or an average of about 39. The ratio of the head width to its depth is 1.4. The ratio of the plated head section to the length of the fourth toe I made out to be 1.72. Thus, there seems to be no question of its identity." "In *arizonae* the head ratio varies from 1.48 to 1.78 and the ratio of the plated head section to the length of the fourth toe, from 1.26 to 1.32."

A specimen of *Xantusia vigilis*, which was collected at Harold, Los Angeles County, was received from Charles M. Bogert in 1930.

Cnemidophorus sexlineatus perplexus (Baird and Girard)

Colorado specimens of this subspecies were obtained 10 miles southwest of Delta, and 13 miles southwest of Delta, in Montrose County, on an arid canyon floor above a small stream where rocks, sand, and gravel were present.

Cnemidophorus tessellatus tessellatus (Say)

Contrary to the current opinion and usage followed in my

revision of the genus *Cnemidophorus* (1931), certain recent workers have adopted Say's original orthography of the specific name of this lizard as *"tesselatus"* instead of *"tessellatus."* This designation was emended long ago by working herpetologists to the spelling with two "l's" and such action is interpreted to be in accordance with article 39 of the International Rules of Zoological Nomenclature. While the English word involved may be spelled in modern dictionaries as either "tessellation" or "tesselation" (or "tessellate" and "tesselate"), appearing both with and without an added "l," these terms are derived from the Latin word *"tessella,"* which would appear to enter properly into latinized combinations (such as specific names) with the use of the two "l's." The Latin word *"tessella"* means "square piece" and the derived term "tessellate" refers to the "formation of squares" or the "laying of checkered work." The application of this cognomen to the present species of *Cnemidophorus* is obvious.

In connection with his remarks on 61 specimens of *Cnemidophorus tessellatus tessellatus* from Lower California, Linsdale (1932) has recently reviewed my treatment of the subspecies as follows: "Although specimens from all the localities above are here placed under one subspecies, following Burt (1931), this treatment of the species is considered to be not entirely satisfactory. The material available, although limited in amount, seems to show too marked a geographical variability to be placed in one race." This generalized comment is followed by: "Of course the individual and age variability in this species show so great a range as to make it difficult to place a proper valuation on the characters that are shown by populations. The actual specimens are, however, insufficient to permit more than an opinion that a reconsideration of the whole species, with more attention given to mean characters of populations and less to overlap shown by individual specimens, would result in more races than Burt's conclusions show."

Upon examination of Linsdale's work, I am unable to find a concrete statement of any type of variation that might prove to be diagnostic of more races of *Cnemidophorus tessellatus* than I have allowed (even in means of populations). While

remarkable contrasts are presented in various local phases of *tessellatus*, these are subjected to a surprising amount of intraspecific atavism, orthogenesis, or homoplasy (i. e., geographical repetition) and any fair treatment of the problem will involve a full consideration of this matter. My own opinions have been formed during the examination of numerous specimens and I have earnestly endeavored to present really significant phylogenetic data, including the mean measurements of populations (pp. 174-177) and the analysis of color pattern trends (pp. 154-157, and 166).

These same remarks in emended form would apply to Linsdale's consideration of my arrangement of the subspecies of *Cnemidophorus hyperythrus* on which he comments as follows: "The treatment here given this species is not in agreement with the conclusions reached by Burt (1931). The difference seems to be more a matter of interpretation of materials than of a difference in the characters of the actual specimens studied. For one thing the geographical groups compared by Burt (p. 235) seem too extensive to show the true nature of geographic variation." It needs to be remarked here that narrowed studies of local variations in species may give undue weight to localized Mendelian orthogenesis or to characteristic physiological adjustments in localized adjacent habitats.

The records of *tessellatus* in the present collection are listed below.

Arizona: 1 mile north of Hackberry, 7 miles northwest of Hackberry, and 2 miles west of Hancock, Mohave County.

California: 11 miles south of Bakersfield, Kern County; and on the sandy banks of the Mohave River, 1 mile south of Oro Grande, San Bernardino County.

Nevada: 4 miles northwest of Fallon, Churchill County; and 1 mile southeast of Fernley, Lyon County.

Utah: 23 miles southeast of Smithville, in the valley between the Confusion and House ranges, in Millard County.

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HELMINTH PARASITES OF THE CHICKEN, GALLUS DOMESTICUS, IN DALLAS COUNTY, TEXAS.

F. M. ADAMS AND S. W. GEISER

During the fall and winter of 1927, a survey of the worm-fauna of the domestic chicken in Dallas County was undertaken in order to determine the character exhibited by such a parasite population. The results of that study were presented in a Master's dissertation by the senior author of this paper, and a statistical resumé was printed as an abstract in the *Anatomical Record* in 1929.[1] The study was begun with the expectation that the viscera of a large number of hosts would be available for examination. It was soon found, however, that time was lacking for the examination in detail of the viscera of large numbers of individuals, as well as for the compilation of complete records of occurring parasites. As the species of the helminth parasites of chickens usually have a world-wide distribution, and as most of the species vary greatly in diverse areas, it was hoped also to secure data on the variations exhibited by the species found in the Dallas area.

The domestic chicken is the most extensively parasitized of all the domestic animals. Meggitt[2] says that this is true of the fowls of Burma, and it could hardly be less true for them in America, as far as number of species of parasites is concerned. This is explainable in part by kinship of the chicken with other aves. The host-parasite relation is greatly complexified through the character and habits of birds. Many parasites of birds show elaborate adaptations to the habits of their hosts. Migratory habits enable birds to act as reser-

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[1] *Adams, F.* and *S. W. Geiser*, "Intestinal Parasites of the Chicken in Dallas County, Texas." Anat. Rec. 44: 266, Dec. 25, 1929.

[2] *Meggitt*, "A Contribution to the Knowledge of the Tapeworms of Fowls and Sparrows." Parasitology 8: 390-410, 1916; *ibid.*, "Tapeworms of Domestic Fowls." Journ. Burma Research Soc. 15: 222-243, 1926.

voirs or carriers, and their range is practically unlimited.[3] The crow, *Corvus cornix, C. Corone,* etc., the jay, *Cypselus apus;* the thrush, *Tetrao urogallus;* and many other wild birds are known to carry the gapeworm, *Syngamus trachea.* The food of many birds, including the chicken, is of so varied a nature that it includes many of the invertebrate animals that serve as intermediate hosts for parasites. The habits of gallinaceous birds (or, generally, those that pick food out of the soil) open avenues for infection by forms of parasites that have free-living periods in their developmental cycle. Nematodes, whose eggs must develop to infective larval stages in the moist soil, are readily picked up in the scratchings, especially where the birds are confined within a limited area. And in the case of aquatic birds the chance of infection especially by trematode worms is perhaps even greater.

Chickens in Dallas County, are not, apparently, infected by trematodes.* In Texas, the occurrence of trematodes is seemingly precluded by the periodic droughts alternating with heavy flooding rains, which tend to upset the balance that must be maintained in aquatic habitats between intermediate and definitive hosts.

MATERIAL AND METHODS

The viscera of twenty-four chickens constitute the material for this brief survey. Eight of the individuals are of unknown origin, but they are included since it is known that they were raised near the city of Dallas. The others come from various parts of the county. As far as possible, chickens were selected that had free range. The viscera were removed, cut apart into separate organs, and washed well or macerated in warm water. Small cestodes, were stripped off with the

[3] This is well illustrated in Lincoln's recent study on returns from banded ducks (Bird-Banding 4: 19-32, January, 1933), where birds banded in Iowa were recovered in California; and ducks banded in Kansas were recovered in all Pacific States, in Mexico, Cuba, Alaska, and all intermediate points.

* *Sprehn, Curt E. W.,* Lehrbuch der Helminthologie, lists 18 Trematode parasites as occurring in European chickens.—Ed.

mucosa membrane, under the dissecting microscope. For the purpose of identification, whole mounts of the scolices and proglottids, of immature, sexually mature, and gravid proglottids were made and stained with Delafield's haematoxylin and Mayer's carmalum. Sagittal sections, from ten to twenty-five micra thick, and stained with Delafield's haematoxylin, or with alum carmine, were also made. The nematodes were studied, either killed or in a living condition. Those killed in alcohol were cleared by adding glycerine and letting the alcohol evaporate; those killed with formalin were cleared in pure liquid phenol and examined before they disintegrated. This latter method was more satisfactory when the material was plentiful, since no shrivelling of the cuticle then occurred to obscure the arangement of structures. Nematodes were fixed in hot 70% alcohol and hot, freshly made 5% formalin. Cestodes were fixed, in a mixture of 70% alcohol and saturated alcoholic-sublimate solution, equal parts. The best results in cestode-fixation, however, seemed to be obtained with a modified Bouin's solution.

RESULTS

Five species of cestode parasites, *Hymenolepis carioca* (Megalhaes), *Amoebatænia sphenoides* (Railliet), *Raillietina cesticillus* (Molin), *R. tetragona* (Molin), and *R. echinobothrida* (Megnin); and four species of nematodes, *Heterakis gallinæ* (Gmelin), *Ascaridia lineata* (Schneider), *Capillaria annulata* (Zeder), and an unidentified "gizzard worm" from two fowls secured near Richardson, were found in the twenty-four chickens examined. The most widely distrubuted species in our material was *Heterakis gallinæ*, with an incidence of 87%; following which were *Ascaridia lineata*, 50% *Hymenolepis carioca*, 37% *Raillietina tetragona*, 28%; *R. cesticillus*, *R. echinobothrida*, and *Capillaria annulata*, 12% each; and *Amoebatænia sphenoides* 8%. The average number of parasites per host was, for *Heterakis gallinæ*, twenty-one; for *Ascaridia lineata*, nine; for *Hymenolepis carioca* (excluding one individual with approximately 20,000 parasites), forty-seven. The distribution of the parasites was general in the county. Details of the individual species follow.

Hymenolepis carioca (Megalhaes). This cosmopolitan species (Africa, Asia, Brazil, Poland, United States) is distributed sporadically in Dallas County. One bird from near Coppell (in the northwest corner of Dallas County) had an estimated population of 20,000 parasites; another, from near Vickery, 200; another from near Tennison Park, 100. Six other birds had from three to 25 parasites each, with an average of thirteen. Our specimens agreed essentially with the descriptions of Ransom (1905) and Gutberlet (1916),[4] with the following variations: Suckers slightly elliptical, 80 x 100 μ; transverse dimension of head, 250 μ; largest proglottids 467 u. wide. Cirrus pouch extends halfway (or slightly more) across the segment, is highly refractive, and may have a convolution. The gravid uterus has a ventral extension that makes it an angular chamber.

Amoebatænia sphenoides (Railliet). This species is also cosmopolitan, having been reported, so far, from Australia, Brazil, Europe, Asia, Canada, and Texas. Only two birds in our material showed infestation; one from near Richardson, with seventy-five; and one from near Vickery, with two.

Local variations from the description given in Stiles & Hassall (1896) are as follows: The largest heads are 220 μ across; suckers, 73 μ in diameter. The retractile rostellum is from 113 to 140 μ long by 53 to 66 μ in complete length. The roots are approximately symmetrical and form a bow 16 μ long that is parallel with the long axis. The strobila begin immediately behind the suckers; and the testes appear in the first segments. They are banana-shaped, about twelve in number, and arranged in the following manner: ((((((0)))))). The mature segments measure 0.2 mm. by 0.8 mm. They tend to become ellipsoidal and break off easily. In these the testes become spheroidal and are to be found along the posterior side of the segment. They vary from 40 to 70 μ in diameter. The vas deferens forms a much-coiled mass that presumably serves as a seminal vesicle, and immediately joins the cirrus pouch. This pouch is 85 μ in length by 14 μ in

[4] Repeated citations are given by date, and are to be found at the end of this paper, under "Literature Cited."

diameter (about twice that of the vas deferens.) It opens to the edge of the segment anteriorally. The vitelline gland is ovoid and 98 by 70 μ in diameter; the ovary is slightly larger. The uterus elongates as it develops and finally bursts, liberating the eggs to fill the parenchyma of the segment.[5] The relative position of the three organs is variable, but may be stated as follows: (a) the vitelline gland is dorsal and median, and indifferently anterior or posterior; (b) the ovary extends slightly to the poral side, and (c) the uterus extends aporally. The eggs are from 15 to 16 μ in diameter.

Raillietina cesticillus (Molin.) This cosmopolitan and abundant species was found near Dallas in only three out of twenty-four fowls. Bird No. 21, from Vickery, harbored a single parasite. Two birds from Tennison Park were hosts to 100 and 150, respectively. Our material accords well with Ransom (1905) and Guberlet's (1916) descriptions, with no especial variations. The two birds showing heavy infection, were emaciated and stunted, although they had been given vermifuges. One, a cock, with 150 parasites of this species (scolices only being found), also harbored fifteen *Ascaridia*, as well as a few of the commoner worms. The other, a pullet, was heavily infected with *Raillietina cesticillus, R. tetragona* (50) and *Hymenolepis carioca* (100). A young cock later investigated showed the presence of 35 worms; but aside from being underweight, exhibited no bad effects. Probably heaviness of infection determines the degree of harm involved in such parasitization.

Raillietina tetragona (Molin). In Dallas County, this species is more generally distributed than any other found in the county. Three birds from near Coppell had from 15 to 35 parasites of this species. Maximum infestation (50) was found in Bird No. 13 (Tennison Park). Other fowls showing this parasite were three birds from near Vickery and Richardson (1 to 4 parasites each.) Our specimens of this species, (also cosmopolitan and abundant,) show no particular variations from Ransom (1905) and Guberlet's (1916) description.

[5] Meggitt (Journ. Burma Research Soc., 15: 222-243, 1926) describes the uterus as persistent but we find the condition in our material to be in accord with the description given by Stiles and Hassall (1896).

Raillietina echinobothrida (Megnin). We have but three records from Dallas County: Coppell (30 parasites), University Park (1 parasite), and Irving (1 parasite.) The species has been reported as moderately frequent in Annam, Argentine, Burma, Formosa, France, India, Tunis, United States, and West Africa. It is described satisfactorily for our material in Ransom (1905) and Guberlet (1916.) No pathological lesions, such as the nodules, etc., described by Ransom were found in our birds.

Heterakis gallinæ (Gmelin.) This, our most abundant local parasite of fowls, is also of world-wide distribution. In our Dallas County material, it occurred in 87 per cent of the birds. Our local material is adequately described in Cram (1927.) This species is considered pathogenic in fowls; but it is a question in our local material whether any notable damage is done to the host, since infection is almost universal. Upon infection, the worms pass at once to the caeca, and remain there. In some cases of moderately high infestation, hyperaemic areas were noted in the caecal valves. Maximum infection for our material, 50; average for 24 birds, 18.3 parasites. Studies made at the University of Minnesota and at the Kansas State Agricultural College show three-fourths, or more, of chickens infested with this parasite.

Ascaridia lineata (Schneider.) This species is second in abundance locally. The maximum infestation was 35; the average infestation for the twelve birds in which this parasite was found was 8.4. Considerable variability in the number and position of the caudal papillae was observed in our specimens. The species was described by Cram (1927). Geographic distribution: Belgian Congo, Brazil, India, Turkey, United States, Zanzibar.

Capillaria annulata (Zeder.) This species was not very abundant in our material, being found in but 3 out of 24 birds. One, from Coppell, had 20 parasites of this species; another, from the same locality, had 5; and a bird from Seagoville had 1. This species has been reported from Europe and the United States. Our material essentially agrees with Cram's (1927) description, except that the bacillary bands in our material

were barely visible. The retracted sheath could be traced for at least 2.5 mm. The chicken is supposedly a normal host for this species; but the turkey is greatly injured by it (Cram, 1926.) The parasite may also be injurious to the chicken. In the fowl we found that a worm had damaged the tissue by an extensive migration, with formation of a pseudomembrane like that described by Hung[6] from the turkey.

The writers desire to acknowledge the helpful suggestions and interest of Dr. Maurice C. Hall and Professor Asa Chandler, during the course of this work.

[6] *Hung, S. L.*, "Pathological Lesions produced by *Capillario annulata*." North Amer. Veterin. 7: 49-50, 1926.

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SOUTHERN METHODIST UNIVERSITY,
DALLAS, TEXAS.

PENNSYLVANIAN OSTRACODA;

A Continuation of the Study of the Ostracoda Fauna from the Wayland Shale, Graham, Texas.

H. N. CORYELL AND R. T. BOOTH

INTRODUCTION

The sample from which the specimens in this paper were taken was collected by the senior author and Mr. Norman Thomas from the Wayland shale member of the Graham formation, one mile west of Graham, Texas, near the Graham-Throckorton Road, west of Salt Creek. This is practically the same as locality 55.14 of the University of Texas Bulletin No. 2132, and is shown in the accompanying map.

We extend our appreciation to those assistants and artists who have helped to make this work possible.

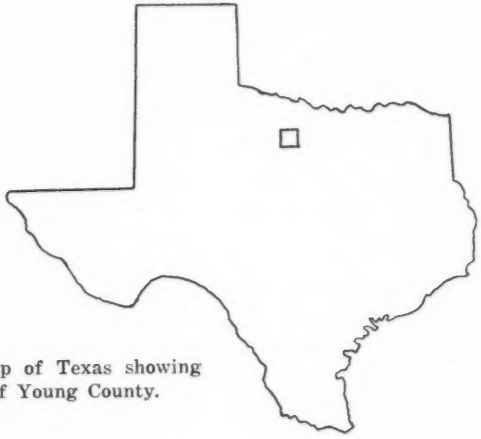
STRATIGRAPHY

The Pennsylvanian sediments of north Texas are essentially shallow water deposits. The period began in the region with conditions favorable for the deposition of the petroliferous limestones and carbonaceous shales which make the Bend Group. At the end of the first epoch there was an elevation of the Llano Mountain area and an uplift of the old land masses to the east. Then followed a deposition of thick beds of sand and gravel interbedded with shale, which are now known as the Strawn Group. These coarse sediments were succeeded largely by calcareous oozes and marls, making up the series of strata forming the Conyon Group. The latter part of the period was marked by a long epoch of oscillating levels of the sea during which beds of clay, sand, and limestone were deposited in somewhat rhythmic succession to form the series of strata which are included in the Cisco Group. The Graham formation has been assigned to the basal formation of the Cisco Group.

In the Brazos River valley the Graham is divided as follows:

Graham formation	Wayland shale Gunsight limestone South Bend shale and sandstone Bunger limestone Gonzales Creek shale and sandstone Jacksboro limestone Finis shale and sandstone

Our present study deals with only the uppermost member. In this fossil locality near Graham the Wayland shale is represented by ten feet of a dark blue, soft, very fossiliferous shale. Ostracodes are very numerous and exclusively marine forms.



Outline Map of Texas showing the location of Young County.

Map of Young County, Texas, showing the location of Graham, one mile west of which the Ostracodes were collected.

Phylum ARTHROPODA

Class CRUSTACEA

Order OSTRACODA Latreille

Family KIRKBYIDAE Ulrich & Bassler 1906

Genus AMPHISSITES Girty 1910

Amphissites centronotus (Ulrich & Bassler) 1906

Plate III, Figs. 1, 2

Kirkbya centronota Ulrich & Bassler, Proc. U. S. Nat. Mus., 1906, Bull. 1446, vol. 30, p. 159, pl. A, figs. 16-17.

Amphissites centronota Harlton, Jour. Paleo., 1927, vol. 1, no. 3, p. 207, pl. 32, figs. 10a, b.

Amphissites centronotus Knight, Jour. Paleo., 1928, vol. 2, no. 3, p. 259, pl. 32, figs. 6a-e; pl. 34, fig. 2. –Delo, Jour. Paleo., 1930, vol. 4, no. 2, p. 160, pl. 12, fig. 9 –Warthin, Okla. Geol. Surv., 1930, Bull. 53, p. 66, pl. 5. figs. 4a-c. –Coryell with Osorio, Amer. Mid. Nat., 1932, vol. 13, no. 2, p. 30; with Billings, ibid. no. 4, p. 184, pl. 18, fig. 9; with Sample, ibid. no. 5, p. 258, pl. 25, fig. 1.

Description. — Carapace small subquadrate; hingeline straight; ventral margin convex; ends rounded up to the cardinal angles; entire surface coarsely reticulate with somewhat concentric arrangement of the depressions; thin marginal flange borders the free edge of each valve; another continuous one is present a few reticulations within the margin ventrally, and meets it at the cardinal angles; a third ridge occurs within the latter, paralleling the end portions distinctly but apparently not present ventrally; subcentral node prominent; hingeline margined by a ridge-like ornamentation that diverges from the contact more anteriorly than posteriorly.

Length, 0.8 mm.; length-height ratio, 2.0.

Amphissites dattonensis Harlton 1927

Plate III, Fig. 3

Amphissites dattonensis Harlton, Jour. Paleo., 1927, vol. 1, no. 3, p. 206, pl. 32, figs. 9a, b; Univ. of Texas, 1929, Bull. 2901, p. 149, pl. 1, figs. 92, b. Warthin, Okla. Geol. Surv., 1930, Bull. 53, p. 64, pl. 4, fig. 15. Coryell with Billings, Amer. Mid. Nat., 1932, vol. 13, no. 4, p. 184, pl. 18, fig. 8; with Sample, ibid., 1932, vol. 13, no. 5, p. 260, pl. 25, fig. 2.

Description. — Carapace small suboblong; hingeline straight; ventral margin almost straight with ends regularly rounded to cardinal angles; strong flange around free edges, with smooth margin; remainder of shell coarsely reticulate; inner carina about three reticulations from the marginal flange and present only ventrally; central node low, finely reticulated, and somewhat elongated; greatest obesity is nearly central; the area postero-dorsal from the central node is more depressed than that towards the antero-dorsal.

Length, 0.7 mm.; length-height ratio, 1.6.

Genus **Girtyites** Coryell and Booth, n. gen.

Genotype *Girtyites spinosus* Coryell & Booth, n. sp.

Description. — Carapace small, subquadrate, apparently equivalved with straight hingeline; free margin flanged; surface reticulated with a subcentral node and a prominent antero-dorsal spine-like protuberance.

This genus differs from Amphissites in lacking the distinctly quadrangular outline, and the secondary flange, interior ridges, and median pit that commonly characterize the latter.

Range: Pennsylvanian.

Girtyites spinosus Coryell and Booth, n. sp.

Plate III, Figs. 4-6

Description. — Carapace small, subquadrate; hingeline profile centrally concave; hingeline contact apparently straight; ventral margin slightly concave; ends rounded to cardinal angles; thin smooth flange around free edges; greatest height near posterior end; subcentral node conspicuous; anterior horn points antero-dorsally and extends vertically downward as a swelling over one-half the distance to the ventral margin; convexity of valve ventricose ventrally, depressed antero-dorsally to the central node; surface coarsely reticulate and arranged concentrically along the free margin slope, more conspicuously posteriorly.

Length, 0.4 mm.; length-height ratio, 1.7.

Holotype — Columbia University, Paleo. Coll. Cat. No. 27544.

Genus **Kirkbyella** Coryell and Booth, n. gen.

Genotype *Kirkbyella typa* Coryell & Booth, n. sp.

Description.—Carapace small, subquadrate to suboblong; hingeline straight; free margin bordered; valves apparently equal; pronounced subcentral sulcus extending up to near the dorsal margin; surface reticulate; differs from Kirkbya in having a sulcus instead of a pit.

Range—Pennsylvanian.

Kirkbyella typa Coryell and Booth, n. sp.

Plate III, Fig. 7

Description.—Carapace small; suboblong; hingeline straight, with pronounced cardinal angles; a smooth, thick border around free edges, showing in lateral view more prominently at the ends than along the ventral border; ventral margin broadly convex in lateral view; ends rounded, the greatest posterior extension median, the greatest anterior extension near the cardinal angle; slightly backward swing, truncation present antero-ventrally; deep postero-central sulcus extending vertically from the smooth margin of the dorsal border to the middle of the valve; a longitudinal swelling forms a ridge just below sulcus, becoming more prominent and narrower anteriorly, and forming the general convexity of the valve posteriorly; the surface within the smooth border is coarsely reticulated.

Length, 0.6 mm.; length-height ratio, 2.0.

Holotype — Columbia University Paleo. Coll. Cat. No. 27545.

Family BAIRDIIDAE Brady and Norman 1892

Genus BAIRDIA McCoy 1844

Bairdia hurwitzi Coryell and Booth, n. sp.

Plate III, Figs. 8, 9

Description.—Carapace subrhomboidal; dorsal margin arched, broadly rounded above hingeline, and nearly straight on anterior and posterior slopes; ventral overlap greatest antero-centrally and somewhat depressed; anterior end narrowly rounded, with backward swing; posterior end

with rounded acumination well below mid-height; overlap of left valve over right on all edges; dorsal contact channelled, straight in middle portion and approximately parallel to edges on antero- and postero-slopes except where it curves out toward the margins at the ends; ventral contact convex, but with reentrant sinuosity anterior of middle; greatest height just posterior of center; ventral view fusiform; maximum thickness below mid-line; interior muscle scar is a rounded pit just above ventral contact sinuosity; surface of valve smooth.

Length, 1.3 mm.; length-height ratio, 1.7.

Holotype — Columbia University Paleo. Coll. Cat. No. 27546.

Bairdia acetalata Coryell & Billings 1932

Plate III, Figs. 10, 11

Bairdia acetalata Coryell & Billings, Amer. Mid. Nat., 1932, vol. 13, p. 173, pl. 17, fig. 5.

Bairdia subelongata Harlton (not Jones & Kirkby), Jour. Paleo., 1927, vol. 1, no. 3, p. 210, pl. 33, fig. 11; Univ. of Texas 1929, Bull. 2901, p. 157, pl. 3, fig. 6a. –Knight, Jour. Paleo., 1928, no. 4, p. 326, pl. 43, fig. 9.

Description. — Carapace long; suboblong; dorsal margin very broadly rounded in the central part; rounded anterior end with backward swing; posterior end roundly acuminate; rather uniform overlap of left valve over right along the dorsal margin; anterior and posterior overlap very narrow; sinuosity in ventral contact is slightly anterior of center; lanceolate in ventral view with greatest thickness slightly posterior of center; surface smooth.

Length, 1.2 mm.; length-height ratio, 2.2.

Bairdia pinnula Coryell and Booth, n. sp.

Plate III, Fig. 14

Description. — Carapace is elongate ovate in lateral view; the overlap is entire, most prominent along the dorsal arch; the ventral margin is nearly straight with the ends curving upward about equally; the posterior acumination is bluntly rounded and lies below the mid-height; the greatest

height is distinctly anterior of the center of the valve; the anterior height is much greater than the posterior when measured equidistantly from the respective ends; the anterior angulation lies high in the dorsal quarter.

Length, 1.06 mm.; length-height ratio, 1.8.

Holotype — Columbia University Paleo. Coll. Cat. No. 27549.

This species differs from *Bairdia hoxbarensis* in the longer posterior slope and greater dorsal overlap, features that make a distinct difference in the lateral view.

Bairdia samplei Coryell and Booth, n. sp.

Plate III, Figs. 12, 13

Description. — Carapace small; short; subrhomboidal; dorsal margin strongly arched, rounded above hinge-line and almost straight on antero- and postero-slopes; ventral margin convex; anterior acutely rounded above mid-line, and with a slight backward swing; posterior with rounded acumination below center; posterior contact is slightly concave and depressed above the apical end and broadly curved to the ventral margin below the posterior apex; anterior contact acumination more acute than the anterior margin; sinuosity in ventral contact sub-central; maximum height anterior of center; surface of valve smooth.

Length, 0.9 mm.; length-height ratio, 1.45.

Holotype — Columbia University Paleo. Coll. Cat. No. 27548.

Bairdia scholli Coryell and Booth, n. sp.

Plate IV, Fig. 3, 4

Description. — Carapace subovate; dorsal margin broadly rounded except for straight postal slope; ventral margin nearly straight to slightly concave in central portion, rounded anteriorly and straight posteriorly; anterior margin rounded with backward swing; posterior acutely and evenly angulate; dorsal contact line of valves convex in middle, with almost straight end slopes as seen in lateral view; ventral contact sinuosity slightly anterior of the middle portion; outline

broadly lanceolate in ventral view; the greatest thickness is posterior of the center and slightly below it; maximum height just in front of the middle; surface smooth.

Length, 1.3 mm.; length-height ratio, 1.9.

Holotype — Columbia University Paleo. Coll. Cat. No. 27550.

This differs from *B. hoxbarensis* Harlton in having a subcentral angulation of the hingeline, and in having the posterior part of the hingeline depressed.

Genus **Silenites** Coryell and Booth, n. gen.

Genus *Silenites silenus* Coryell & Booth, n. sp.

Description. — Carapace small, short (height greater than one-half the length); dorsal margin highly arched, with anterior and posterior portions sloping steeply in a broad arch to the end margins; the dorsal contact arched or straight centrally with the ends concave, straight or convex; the ventral border straight or concave; surface of valve smooth, without distinct ornamentation.

This genus resembles *Bythocypris* in outline except the posterior ventral margin is much more broadly rounded, making the line of greatest length well above the ventral contact.

It differs from *Bairdia* in lacking the distinct posterior acumination and it does not possess the conspicuous ventral furrow present in the species of *Bairdiocypris.*

The species *Bythocypris gallowayi* Coryell & Osorio and *B. faba* Coryell & Osorio should be included here. The Carboniferous species identified as *Bythocypris bilobata* (Münster) or *Cythere bilobata* Münster from Bavaria, England, Belgium, Russia and Mongolia could be placed here also.

Silenites silenus Coryell and Booth, n. sp.

Plate IV, Figs. 1, 2

Description. — Carapace subrhomboidal; dorsal margin very highly arched with nearly straight antero- and postero-slopes; ventral border broadly concave in central portion; ends rounded, the anterior with a slight dorsal contact angulation; dorsal contact line slopes downward posteriorly

in the middle portion, making the width of the overlap equal to about one-fourth the height of the valve below the dorsal contact; the ends of the dorsal contact are slightly concave; left valve much larger than right; overlap narrow along the ventral border, the widest portion just posterior of the middle; fusiform in ventral view; ventricose centrally; rather evenly convex in end view; surface smooth.

Length, 1.1 mm.; length-height ratio, 1.6.

Holotype — Columbia University Paleo. Coll. Cat. No. 27565.

Genus BYTHOCYPRIS Brady 1880

Bythocypris pediformis Knight 1928

Plate IV, Fig. 5

Bythocypris pediformis Knight, Jour. Paleo., 1928, vol. 2, no. 4, p. 326, pl. 44, fig. 3a-c. –Warthin, Okla. Geol. Surv. 1930, Bull. 53, p. 74, pl. 6, fig. 6a, b. –Coryell & Sample, Amer. Mid. Nat. 1932, vol. 13, no. 5, p. 267, pl. 25, fig. 18.

Description. — Carapace subelliptical; dorsal margin regularly rounded; ventral border broadly convex, almost straight in its central portion; anterior margin round in lateral view; posterior moderately convex, with a postero-ventral obtuse acumination; overlap narrow and entire; lanceolate in ventral view with maximum thickness in postero-ventral quarter; surface smooth.

Length, 0.5 mm.; length-height ratio, 1.6.

Genus HEALDIA Roundy 1926

Healdia colonyi Coryell and Booth, n. sp.

Plate IV, Figs. 9, 10

Description. — Carapace small; dorsal margin arched, convex anteriorly and slightly concave posteriorly; ventral border broadly convex; posterior margin narrowly rounded; anterior margin more broadly rounded; overlap of left over right slight and not apparent along depressed postal slope as seen in lateral view; outline in dorsal view lanceolate with maximum convexity just posterior of center and extended back rather high to the ventral and dorsal spines; the

ventral spine is more blunt than the dorsal; surface smooth.

Length, 0.5 mm.; length-height ratio, 1.5.

Holotype — Columbia University Paleo. Coll. Cat. No. 27553.

Healdia simplex Roundy 1926

Plate IV, Fig. 6

Healdia simplex Roundy, U. S. Geol. Surv., 1926, Prof. Paper 146, p. 8, pl. 1, figs. 11a-c.—Coryell with Billings, Amer. Mid. Nat., 1932, vol. 13, No. 4, p. 179, pl. 17, fig. 15; with Sample, ibid., No. 5, p. 268, pl. 26, fig. 1.

Description. — Carapace small; anterior dorsal margin arched; depressed postal slope as seen in lateral view straight near greatest height, to concave near the posterior end; ventral border broadly convex; anterior margin regularly rounded; dorsal posterior margin slightly acuminate; overlap is narrow on the free margin, very little wider along the antero-dorsal margin, and apparently lacking on the depressed postal slope as seen in lateral view; outline lanceolate in ventral view with maximum thickness near the center of the posterior half; surface smooth.

Length, 0.7 mm.; length-height ratio, 1.5.

Healdia masoni Coryell and Booth, n. sp.

Plate IV, Figs. 7, 8

Description. — Carapace very small; dorsal margin arched; the anterior end distinctly lower than the posterior; ventral margin broadly convex with more narrowly rounded extremities; end margins well-rounded, the posterior more bluntly; overlap narrow, most pronounced antero-dorsally, and not apparent on the postal slope; dorsal contact of right valve sub-angulate near center at point of greatest height; dorsal view wedge-shaped, with maximum thickness near the posterior end; the surface of each valve is finely granulose and regularly convex anterior to the vertical posterior crest; behind the low crest the convexity dips steeply to the posterior border.

Length, 0.3 mm.; length-height ratio, 1.7.

Holotype — Columbia University Paleo. Coll. Cat. No. 27555.

Genus WAYLANDELLA Coryell & Billings 1932

Waylandella cuyleri Coryell and Booth, n. sp.

Plate V, Fig. 5

Description. — Carapace small, sub-elliptical; dorsal margin very broadly convex; ventral margin slightly concave with rounded extremities; ends rounded, the anterior somewhat more truncated dorsally; right valve larger than left and overlapping on the entire margin, greatest overlap centro-ventrally; the greatest thickness near the center of the posterior half; valves equally convex in end view; postero-ventral spine short, pointed, and extends beyond the margin; surface finely granulose to smooth.

Length, 1.0 mm.; length-height ratio, 1.8.

Holotype — Columbia University Paleo. Coll. Cat. No. 27556.

Genus **Burlella** Coryell and Booth, n. gen.

Genotype *Burlella pecanata* Coryell & Booth, n. sp.

Description. — Carapace suboblong; hingeline nearly straight; right valve larger than left, overlapping it on the free edges and dorsal extremities; anterior end of each valve marked by an irregular U-shaped depression with the ends of the "U" terminating in spinous or knob-like projections, the ventral one larger and apparently hollow; a low swelling is located near the dorsal posterior; surface of the valve smooth to finely granulose.

Range — Pennsylvanian.

Burlella pecanata Coryell and Booth, n. sp.

Plate V, Figs. 12-14

Description. — Carapace small; suboblong; the dorsal margin is nearly straight; posterior end narrowly rounded; anterior end somewhat truncated ventrally; the ven-

tral margin slightly convex centrally; overlap of right valve over left is nearly of equal width along the free edge and anterior cardinal extremity and more prominent at the posterior cardinal extremity; hingeline depressed along the anterior half; an arcuate flattened ridge near anterior end extends from the antero-dorsal contact to a blunt spine above antero-ventral contact; a slightly depression is present in dorsal portion of valve just posterior of the center. The specimen is pecan-shaped in dorsal view with greatest thickness anterior; surface finely granulose to smooth.

Length, 0.9 mm.; length-height ratio, 1.8.

Holotype — Columbia University Paleo. Coll. Cat. No. 27557.

Genus **Artifactella** Coryell and Booth, n. gen.

Genotype *Artifactella tomahawki* Coryell & Booth, n. sp.

Description. — Carapace small; suboval; hingeline arcuate; greatest thickness anterior; right valve larger than left, overlapping on ventral and dorsal margins; a shallow vertical constriction is evident a little anterior of the center of the valve; valve smooth.

Range — Pennsylvanian.

Artifactella tomahawki Coryell and Booth, n. sp.

Plate V, Figs. 1, 2

Description. — Carapace small; suboval; hingeline broadly arcuate; ventral margin slightly convex with rounded extremities; ends rounded; the posterior height is much lower than the anterior; the greatest length is in the ventral half; the posterior margin slopes upward from the greatest posterior extension in a broad curve to the position of greatest height; the anterior cardinal extremity is angulated at the junction with the nearly straight dorso-anterior margin; right valve overlaps left on dorsal and ventral margins, greatest at their centers; the ventral overlap is much greater than the dorsal; maximum thickness near the center of the anterior half; greatest height a little anterior of the center where also

is located the vertical shallow constriction; surface smooth to very finely granulose.

Length, 0.65 mm.; length-height ratio, 1.3.

Holotype — Columbia University Paleo. Coll. Cat. No. 27558.

Family CYTHERELLIDAE Sars 1865

Genus CAVELLINA Coryell 1928

Cavellina subpulchella Coryell 1928

Plate V, Figs. 3, 4

Cavellina subpulchella Coryell, Jour. Paleo., 1928, vol. 2, p. 93, pl. 11, fig. 9—Warthin, Okla. Geol. Surv., 1930, Bull. 53, p. 79, pl. 7, figs. 4a, b.

Description. — Carapace subovate; dorsal margin arched; ventral border broadly convex; ends of valves rounded, the anterior regularly and the posterior more acutely rounded above mid-line; the greatest overlap of right valve over left is located mid-dorsally and mid-ventrally; outline lanceolate in dorsal view, with maximum thickness at the well-defined posterior chamber; surface of valves smooth.

Length, 1.1 mm.; length-height ratio, 1.5.

Genus CYTHERELLA Jones 1849

Cytherella footei Coryell and Booth, n. sp.

Plate IV, Fig. 11

Description. — Carapace sub-ovate; dorsal margin strongly arched, narrowly rounded in middle and straight toward the extremities; ends of valves rounded, the posterior end being somewhat more acuminate just above the middle; ventral margin strongly arched with the greatest overlap just anterior of center; dorsal overlap wide, arched, and conspicuous over the central three-fourths of the hinge margin, reaching a little farther towards the posterior than toward the anterior before it tapers to the width occurring on the ends; ventral contact slightly concave; the thickest portions is located a little behind the center of the valves; surface is apparently smooth.

Length, 0.9 mm.; length-height ratio, 1.5.

Holotype — Columbia University Paleo. Coll. Cat. No. 27560.

Genus **Birdsallela** Coryell and Booth, n. gen.

Genotype *Birdsallella simplex* Coryell & Booth, n. sp.

Description. — Carapace small; outline cytherelloid; hingeline arcuate; left valve larger than right; subcentral vertical constriction; anterior convexity ends rather abruptly at the curved anterior crest where the surface slope changes abruptly and dips steeply to the anterior margin; surface smooth.

Birdsallella simplex Coryell and Booth, n. sp.

Plate V, Figs. 6, 7

Description. — Carapace elongate; subelliptical; dorsal margin broadly convex in middle portion and more rounded toward extremities; ventral margin apparently straight centrally with ends rounded; ends of valves rounded, the anterior being somewhat acuminate above its mid-line; overlap of left over right very narrow, most pronounced postero-dorsally; valves constricted vertically just anterior to the center; dorsal view more or less wedge-shaped, with greatest thickness in anterior half; surface marked by an anterior, outwardly convex, vertical ridge, highest centrally, and dying out dorsally and ventrally near the borders; a marginal flattening of the posterior end is slight but quite evident; surface of valves smooth.

Length, 1.0 mm.; length-height ratio, 2.1.

Holotype — Columbia University Paleo. Coll. Cat. No. 27561.

Family BEYRICHIIDAE Ulrich 1897

Genus HOLLINELLA Coryell 1928

Hollinella kellettae Knight 1933

Plate V, Figs. 8-10

Hollina ulrichi Knight (in part), Jour. Paleo., 1928, vol. 2, p. 237, pl. 31, figs. 4a, b.

Hollinella kellettae Knight in Kellett, Jour. Paleo., 1933, vol. 7, No. 1, p. 70.

Description. — Carapace suboblong; equivalved; dorsal margin straight, with obtuse cardinal angles; ventral margin broadly convex; anterior rounded, with backward swing; posterior margin is nearly straight from the cardinal angle to the free marginal frill which starts at the posterior extremity of the shell where it is ventrally enrolled to form an exterior tunnel cavity; anteriorly the flange flares slightly outward and disappears on the antero-ventral portion of the shell; the flange is marked by radiating grooves; the anterior node appears hemispherical; posterior node is much lower, smaller, and more elliptical; a pronounced median sinus lies between the nodes, limited below by the curved transverse swelling that joins the two major nodes; the surface is coarsely pappilose with a few spinose forms occurring here and there; the spinose granules are more numerous and more regularly arranged along the anterior frill-less margin.

Length, 1.1 mm.; length-height ratio, 1.7.

Family KLOEDENELLIDAE Ulrich & Bassler 1923

Genus JONESINA Ulrich & Bassler 1908

Jonesina grahamensis Coryell and Booth, n. sp.

Plate V, Figs. 11, 12

Description. — Carapace suboblong; hingeline straight and anteriorly depressed in lateral view; ventral margin straight with rounded ends; anterior border truncated ventrally; posterior acutely rounded below mid-line and truncated above it; left valve overlaps right along the free edges; greatest convexity near the center of the anterior half of the valve; sulci shallow, and more or less indefinitely limited; surface finely pitted and in some places undulating.

Length, 0.8 mm.; length-height ratio, 1.7.

Holotype — Columbia University Paleo. Coll. Cat. No. 27563.

Family PRIMITIIDAE Ulrich & Bassler 1923

Dilobella texana Coryell and Booth, n. sp.

Genus DILOBELLA Ulrich 1897

Plate V, Fig. 13

Description. — Carapace small, subquadrate; hingeline straight; valves equal; ventral margin strongly convex; ends rounded and posterior more acutely than the anterior; sub-central deep, narrow sulcus, starting from near the dorsal edge and extending down about half way to the ventral border, separating the valve into two bulbous lobes, the posterior lobe the larger and rounded to the margin; anterior lobe bordered anteriorly by a steep slope and a narrow marginal shelf; greatest height nearly central; surface smooth.

Length, 0.7 mm.; length-height ratio, 1.5.

Holotype — Columbia University Paleo. Coll. Cat. No. 27564.

Dilobella texana differs from the type of the genus in having a straight hingeline as seen in lateral view and a median sinus that extends only to the center of the valve. *D. texana* is unlike *Kirkbyina inflata* Harlton in outline and location of the greatest thickness.

COLUMBIA UNIVERSITY,
NEW YORK CITY

PLATE III

1, 2. Amphissites centronotus (Ulrich & Bassler)
1. Left valve, 2. Dorsal view. x 45

3. Amphissites dattonensis Harlton
Left valve, x 45

4–6. Girtyites spinosus Coryell & Booth, n. gen., n. sp.
4. Ventral view, 5. Right valve, 6. Dorsal view, x 80

7. Kirkbyella typa Coryell & Booth, n. gen., n. sp.
Right valve, x 50

8, 9. Bairdia hurwitzi Coryell & Booth, n. sp.
8. Ventral view, 9. Right valve, x 30

10, 11. Bairdia acetalata Coryell & Billings
10. Right valve, 11. Ventral view, x 30

12, 13. Bairdia samplei Coryell & Booth, n. sp.
12. Ventral view, 13. Right valve, x 30

14. Bairdia pinnula Coryell & Booth, n. sp.
Right valve, x 30

PLATE III

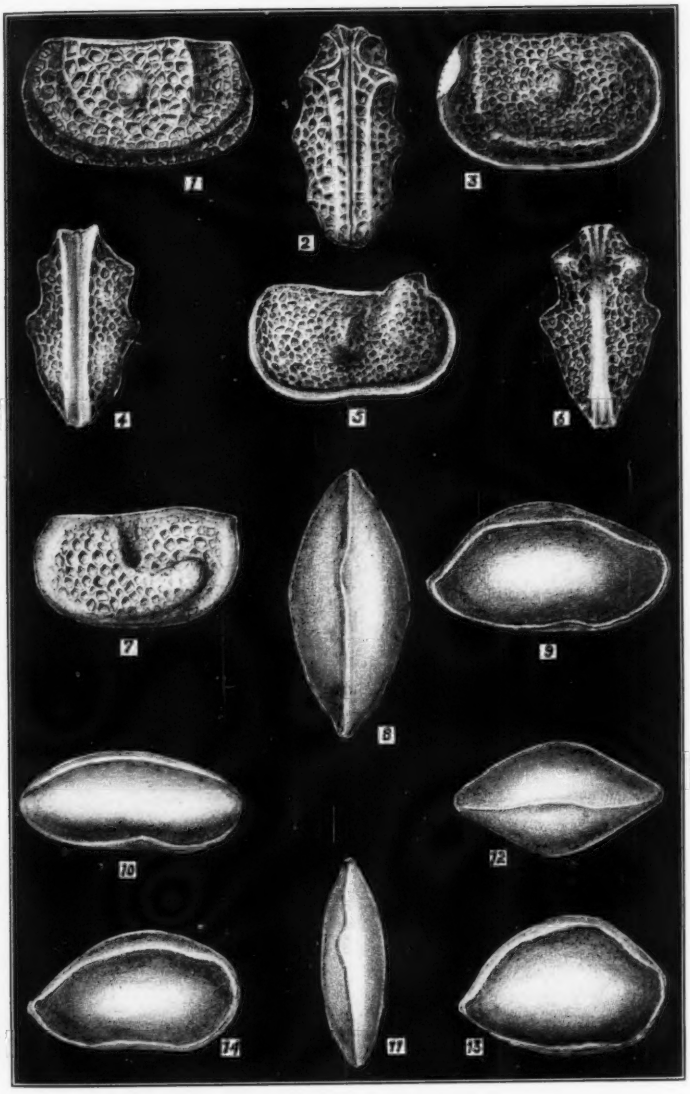


PLATE IV

1, 2. Silenites silenus Coryell & Booth, n. gen, n. sp.
1. Right valve, 2. Dorsal view, x 35

3, 4. Bairdia scholli Coryell & Booth, n. sp.
3. Right valve, 4. Ventral view, x 25

5. Bairdia pediformis Knight
Right valve x 55

6. Healdia simplex Roundy
Right valve, x 45

7, 8. Healdia masoni Coryell & Booth, n. sp.
7. Right valve, 8. Dorsal view, x 90

9, 10. Healdia colonyi Coryell & Booth, n. sp.
9. Right valve, 8. Dorsal view, x 90

11. Cytherella footi Coryell & Booth, n. sp.
Left valve, x 30

12–14. Burlella pecanata Coryell & Booth, n. gen., n. sp.
12. Dorsal view, 13. Left valve, 14. Ventral view, x 30.

PLATE IV

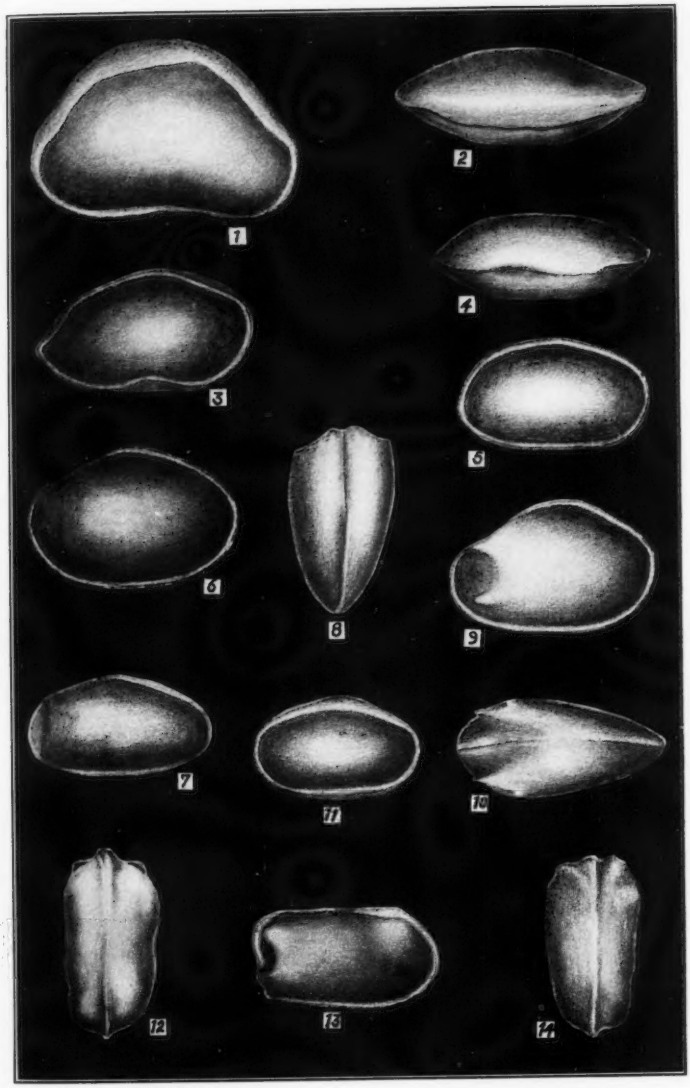


PLATE V

1, 2. Artifactella tomahawki Coryell & Booth, n. gen., n. sp.
1. Left valve, 2. Dorsal view, x 60

3, 4. Cavellina subpulchella Coryell
3. Left valve, 4. Dorsal view, x 30

5. Waylandella cuyleri Coryell & Booth, n. sp.
Right valve, x 35

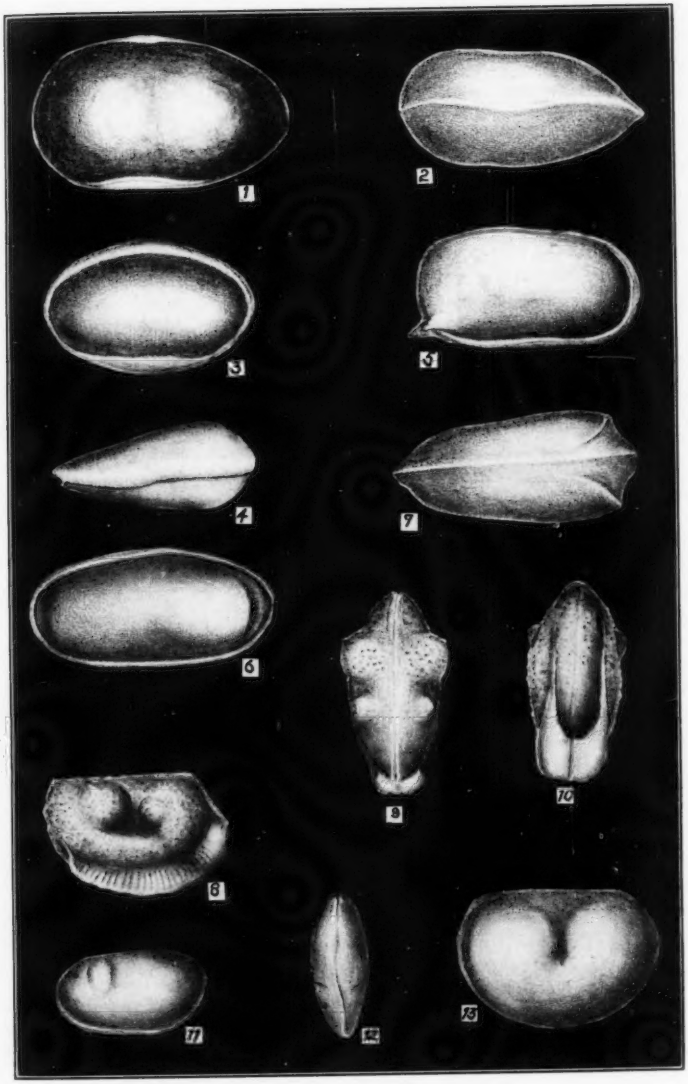
6, 7. Birsallella simplex Coryell & Booth, n. gen., n. sp.
6. Left valve, 7. Dorsal view, x 35

8–10. Hollinella kellettae Knight
8. Left valve, 9. Dorsal view, 10. Ventral view, x 25

11, 12. Jonesina grhamensis Coryell & Booth, n. sp.
11. Right valve, 12. Dorsal view, x 30

13. Dilobella texana Coryell & Booth, n. sp.
Right valve, x 45

PLATE V



REVERSAL OF VALVE SIZE AND HINGE STRUCTURE IN A SPECIES OF THE GENUS CYTHERIDEA

C. I. ALEXANDER AND C. W. ALEXANDER

The two valves comprising the carapace of ostracodes are characteristically more or less strongly asymmetrical. In some genera, one valve is much larger than the other, and overlaps it strongly either along the dorsal or ventral margin, or both. In other genera, on the contrary, the asymmetry is very slight, and may even be imperceptible.

In the genus *Cytheridea*, as in most of the genera of the family Cytheridae, the left valve is characteristically larger than the right, and overlaps it distinctly around the entire periphery. The hinge of *Cytheridea* (fig. 1) consists, in the

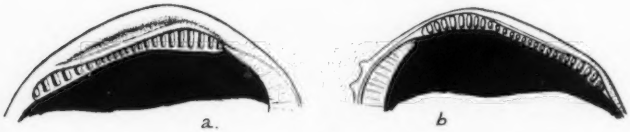


Fig. 1. Hinge of *Cytheridea plummeri* Alexander, illustrating hinge structure typical of the genus; a, left valve; b, right valve. Scale same as in Figure 2.

right valve, of two elongated teeth, one at each end of the hinge line. These teeth each bear several cusps, and are connected by a narrow, finely crenulate bar. The anterior tooth, in most species, is larger and broader than the posterior, and the cusps are ridge-like and set at right angles to the long axis of the tooth. In the left valve are notched terminal sockets, corresponding to the teeth of the right valve. A narrow bar is attached at each end to the dorsal edge of the valve, at

a point just above the middle of the terminal sockets, but lies below and is separated by a more or less distinct groove from the dorsal margin, except at the ends. This bar and groove are very distinct in species characterized by a strongly arched dorsal margin, but may be somewhat obscure in species with an elongated carapace and a low, flat dorsal arch. Below the bar is a finely arched pitted groove, which connects the notched terminal sockets, and into which the crenulate bar of the right valve fits.

The writers have recently discovered, in the Taylor formation of the Upper Cretaceous of Texas, a species of the genus *Cytheridea*, in which the right valve of some individuals is larger than the left.

Large numbers of individuals of the species were examined. The ratio of abnormal specimens, in which the right valve was larger than the left, to normal ones was found to vary greatly at different localities, but the extremes of variation were recorded at localities where the species was represented by but few individuals. Wherever large numbers of specimens were collected, about seventy-five per-cent were found to have the right valve larger than the left.

The abnormal individuals exhibited not only a reversal of valve size, but of hinge structure, the teeth and crenulate bar normally characteristic of the right valve occurring in the left, and the notched sockets and groove in the right (fig. 2).

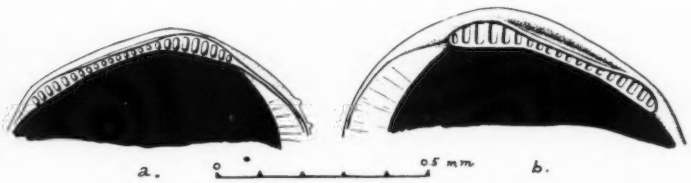


Fig. 2. Hinge of *Cytheridea insolita* Alexander and Alexander, n. sp., exhibiting reversal of typical hinge structure; a, left valve; b, right valve.

Order OSTRACODA Latreille

Suborder PODOCOPA Sars

Family CYTHERIDAE Baird, 1850

Genus CYTHERIDEA Bosquet, 1852

Cytheridea insolita Alexander and Alexander, n. sp.

Figs. 2, 3.

Carapace in side view, triangular, highest slightly anterior to middle. Height equal to about two-thirds of length. Dorsal

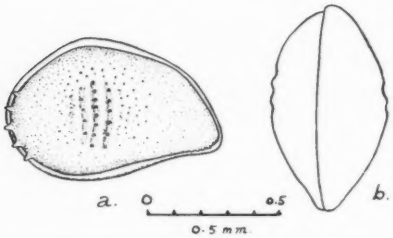


Fig. 3. *Cytheridea insolita* Alexander and Alexander, n. sp., holotype; a, left valve view; b, dorsal view, outline.

margin strongly arched. Ventral margin gently convex in anterior half, slightly sinuate in posterior half. Anterior end broadly rounded. Posterior end with subacute postero-ventral angle. In dorsal view, valves strongly and evenly convex, widest at middle; ends similar, subacute.

Length of holotype, fig. 3, 0.85 mm,, height, 0.55 mm., width, 0.45 mm.

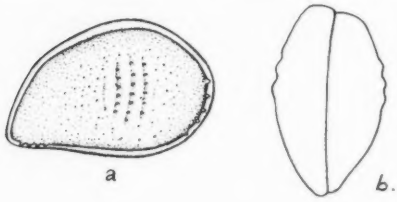


Fig. 4. *Cytheridea plummeri* Alexander; a, right valve view; b, dorsal view, outline. Same scale as Fig. 3.

C. insolita occurs in the Wolfe City sand and in the Pecan Gap and Rodgers chalk members of the Taylor formation, and in the upper Taylor clays immediately overlying the Pecan Gap.

It is closely similar, and is believed to be derived from *C. plummeri* Alexander,[1] which is found in the lower Taylor. The chief feature distinguishing the two species is that in *C. plummeri*, the anterior end, in dorsal view, is very broad and roundly truncated, while in *C. insolita* it is narrow and subacute. (Compare figs. 3 and 4.)

Holotype, No. 0-24115.1 Alexander Collections, collected at an exposure of Pecan Gap chalky clays in a roadside ditch 0.7 miles west of Forney on the Forney-Mesquite road.

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[1] Alexander, C. I., Ostracoda of the Cretaceous of North Texas, Univ. Texas Bull. No. 2907, p. 73, pl. 5, figs. 5-8, 1929.

BOOK REVIEWS

A MANUAL OF FORAMINIFERA, by J. J. Galloway. The Principia Press, Bloomington, Indiana, 1933. 483 pp. $6.50.

Dr. Galloway's *Manual of Foraminifera* is a combination text and reference book. Its greatest usefulness will be as a reference book for taxonomists. With the exception of the first thirty-six pages, which deal briefly with general principles such as evolution, morphology, and related topics, the book consists of systematic descriptions of the families and genera of the foraminifera recognized as valid by the author. As a text, it is primarily suited for advanced and mature students who have had a preparatory background of courses in general biology and paleontology. The chief defects of the Manual as a text book are the brevity of its treatment of general principles, and the failure of the author to maintain a strictly objective viewpoint toward the controversial questions regarding the phylogeny of the foraminifera. Its use as a text book will necessitate a great deal of supplementary lecturing and reading assignments, first, in order to make up for the deficiencies in the treatment of general principles, and second, in order to inform the student that, as in other controversial matters, there are two sides to the questions regarding the phylogeny of the foraminifera.

The first division or section of the manual discusses the Foraminifera as Protozoa, briefly describing the living animal, and indicating the tazonomic position of the Foraminifera.

This is followed by a four-page historical review of the classification of the foraminifera, beginning with D'Orbigny's allocation of the "foraminiferes" as one of the orders of the Cephalopoda, in 1826. The subsequent attempts of the same and later students to arrange the foraminifera in orders, families, and genera are described in chronological order. Each discussion includes a statement of the number of families and genera recognized by the student in question, a description of the basis of classification employed, and a discussion of the merits and defects of the method and the resulting systematic arrangement. A list of thirty-two references on classification follows the review.

The next section is devoted to a discussion of the philosophy of taxonomy, stressing the modern view as to the importance of the application of the biogenetic law, and insisting on a phylogenetic classification of the foraminifera, in contrast to the purely morphological classifications of many of the earlier students. This section consists of six pages. The last four are devoted to an exposition of the author's personal convictions as to the phylogeny of the foraminifera, and stresses the postulates that the most primitive forms are spheroidal, and have given rise to tubular, multilocular and irregular forms, and that the

primitive wall material is gelatinous, from which developed the chitinous and calcareous, and finally, the arenaceous. The section is concluded with a list of the characters regarded by the author as of family, generic, specific and varietal importance.

The next eight pages are devoted to a discussion of evolution and its corollaries. This section is introduced by the statement that the great abundance, convenient size, and the presence of two or more phylogenetic stages portrayed in the same individual make the foraminifera especially suitable for the study of many principles of paleontology and evolution. Students of the foraminifera will heartily agree with this statement, and the exposition which follows will prove a revelation to many teachers of general paleontology and evolution. The corollaries of evolution, variation, recapitulation, tachygenesis, atavism, orthogenesis, convergence or isomorphism, parallelism, adaptation, extinction, and provincial and cosmopolitan faunas are discussed in some detail, with citation of numerous illustrations of each of these phenomena among the foraminifera. To the teacher, this will prove one of the most valuable portions of the book, as it includes not only a brief theoretical discussion of the various factors and corollaries of evolution, but illustrates these with well-chosen, concrete examples. The modern school of genetecists may object to some of the theoretical considerations, but paleontologists will find ample support for their belief in recapitulation and orthogenesis in the multiplied illustrations of these phenomena cited by Galloway.

This is followed by a short section on the morphology of the test, including a description of the materials used in constructing the walls of the test, variations in the arrangement of chambers and form of the test, the different types of apertures and surface ornamentation, and definitions of the descriptive terms applied to the parts of varied types of test.

Next, there are brief sections on the reproduction of the foraminifera, including a description of the phenomena of dimorphism and a discussion of the theory of polymorphism, and on the geographic and geologic distribution of the foraminifera.

In the latter section, the author finds much to substantiate his theory as to the primitive character of the calcareous test. He accepts without hesitation or qualification the reported occurrence of calcareous shelled foraminifera in the Cambrian of England, Russia, and New Brunswick. He does not mention the fact that the specimens described by Jones from the Cambrian of England are so similar in appearance to Cretaceous species that many students have suspected an accidental mixing or contamination of samples, that the specimens described by Ehrenberg from the Cambrian of Russia are internal casts, and that many who have examined the objects determined by Matthews as specimens of *Globigerina* and *Orbulina* from the Cambrian of New Brunswick, have pronounced them microscopic concretions. In further support of his

theory, he includes in the foraminifera, under the new generic name *Cayeuxina*, certain minute objects described by Cayeux from pre-Cambrian shales of Brittany, having siliceous walls which Galloway supposes to represent replacement of the original calcareous shell. The earliest arenaceous foraminifera, according to Galloway, are Silurian in age, although there are several authentic records of arenaceous species from the Ordovician.

The taxonomic portion of the book begins with page 37. The author recognizes 35 families, most of which are divided into two to four subfamilies, and 542 valid genera. Other students of the foraminifera will disagree with many features of Galloway's classification, but they will also find important information here which is not included in any other work on the foraminifera.

Under each family name, the author gives the reference to the first use of that name in the literature. The valid name for each family is determined by the law of priority, and the application of the law has necessitated the abandonment of several familiar family names in favor of earlier ones. Following the reference to the valid family name, there is a definition of the family characters, and a phylogenetic tree, showing the ancestor of the family, the division into subfamilies, and the relationship of the genera. This is followed by a discussion of the evolution and classification of the family, which amounts practically to an explanation of the arrangement of the family tree.

Keys are employed throughout to facilitate the allocation of specimens. If the family is subdivided into subfamilies, a key to these follows the discussion of the evolution and classification. The characters of each subfamily are summarized in turn, and under each is given a key to the included genera.

Several of Galloway's family groups are too inclusive, the subfamilies really deserving of family rank. At least three distinct families are included, for example, under the name Astrorhizidae. Galloway admits that this family, as he defines it, is probably polyphyletic. He could have more nearly achieved monophyletic groupings by recognizing the family groups commonly accepted by other paleontologists.

Most paleontologists will disagree with the arrangement of some of the family trees, and with family assignment of many of the genera. In several cases genera are indicated as derived from ancestors not only from strata much later than the supposed descendant, but also exhibiting a much more advanced and specialized structure. For example *Bolivina* (Jurassic to Recent) is indicated as derived from *Bolivinella* (Eocene to Recent), and *Marginulina* (Triassic to Recent) from *Vaginulina* (Triassic to Recent). In the latter instance the supposed ancestor is known to occur in strata at least as early as the descendant, but both *Bolivinella* and *Vaginulina* exhibit certain specialized features which disqualify them as ancestors of the genera supposed to have been derived from them.

The generic descriptions are the most valuable feature of the *Manual*. The law of priority is applied to determining valid names of genera, and, as in the case of the families, several well-established names are discarded for earlier ones. Under the generic name is listed the author, date, genotype, and the reason why it is the type (monotypic genus, genotype by subsequent designation, etc.), a reference to the original generic description, the age and original locality of the genotype, important references in addition to the original description, and all determined synonyms. This is followed by a summary of the generic characters, and finally by a brief statement of the geologic range and the habitat of living species.

Each genus is illustrated by a figure of the genotype. The figures are usually the type figures, supplemented, where necessary, by figures from later descriptions of the species or by original figures. The illustrations are arranged on plates, of which there are 41. The figures are excellent, and serve admirably their primary purpose of illustrating the generic characters.

Following the systematic descriptions is a section on miscellaneous genera, consisting of lists of unrecognizable genera, with a reference to the description of each, nomina nuda, invalid names, with references and a statement of the reason for the rejection of each, and genera erroneously referred to the foraminifera with references and a statement of the probable taxonomic relationships.

These lists are followed by an extensive glossary of descriptive terms, and an index to the families, subfamilies and genera, in which both valid names, synonyms and invalid names are included.

In summary, the book contains a wealth of information indispensable to the taxonomic paleontologist, some of which is not available in any other book on the foraminifera, and, supplemented by lectures and reading assignments, could be used satisfactorily as a text.—C. I. ALEXANDER.

LEHRBUCH DER HELMINTHOLOGIE, by Curt E. W. Sprehn. Borntraeger, Berlin, 1932. pp. 998 with 374 illustrations. RM. 96,00.

The sub-title of this volume is "a natural history of worms occurring as parasites in the mammals and birds of Germany, with special reference to the helminths of man and the more important domestic animals." The volume is divided into two main parts. The first part discusses the natural history of helminths in general. This part gives some exact notions of parasitism, its origin and distribution. This is followed by a brief notice of the nomenclature and the system adopted in the book. Then come, in turn, the life histories of each of the five classes of helminths recognized by the author, the Trematodes, Cestodes, Nematodes, Acanthocephala and Pentastomida. A chapter each is

devoted to the medical aspects of helminthology, its technique and its history.

The second part of the book, comprising 725 pages, gives the natural history of 365 genera of helminths. There is a list of 73 mammalian and 245 avian hosts. Man is listed as host for 112 species; the domestic dog, for 101 species; and the house-cat, for 85 species. An alphabetical list of genera and species, with their synonyms, follows. There is a good table of contents, and a bibliography. The bibliography lists 43 works of general reference, eight current magazines, and 1253 articles.

This volume is a credit to the scholarship and craftsmanship of the author and the publisher. The former has given us the full benefit of ripe and profound scholarship, while the latter has turned out a product that is mechanically perfect. No book known to this reviewer treats the subject so exhaustively and so thoroughly. No worker in this field can afford to ignore this book.—F. WENNINGER.

PLANTS OF ROCKY MOUNTAIN NATIONAL PARK, by Ruth E. Ashton. Government Printing Office, Washington D. C., 1933. 157 pp., pls. 15, figs. 100.

Many visitors to the Rocky Mountain National Park have admired its rich and varied plant-life and may have desired information regarding its most distinctive representatives. It is mainly for the benefit of these travellers that this little volume has been compiled and it seems to correspond well to that need. Many species are well illustrated and the most characteristic are sufficiently described to render the book serviceable to those whose interest in the plant-life of the Park is their sole concern with botany, as well as to the professional naturalist. There is also a short discussion of the life zones and ecological topics of general interest. A key to the woody and herbaceous plants is included while a glossary of botanical terms with figures showing the commoner leaf and inflorescence types is added. A bibliography of 39 titles assists in directing one to sources of more detailed information. Guides of this kind will always be welcomed by an interested public and one hopes that similar books will be prepared for other park areas.—TH. JUST.

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